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THE EFFECTS OF WORK-RELATED VALUES ON  
COMMUNICATION BETWEEN R&D GROUPS

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THE EFFECTS OF WORK-RELATED VALUES ON  
COMMUNICATION BETWEEN R&D GROUPS

A DISSERTATION

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by

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Evanston, Illinois

August 1970

# THE EFFECTS OF WORK-RELATED VALUES ON COMMUNICATION BETWEEN R&D GROUPS

Charles Fowler Douds

## SUMMARY

This research is a part of a larger project concerned with the "liaison, interface, coupling, technology transfer" (LINCOTT) processes that occur in research and development. These refer to the way information, ideas, and techniques move from one point to another in the research, development, engineering, and manufacturing community. "Coupling" refers to information transfer among such groups and the utilization made of that information. A number of factors that appear to structure the LINCOTT process are described.

The purpose of this research was to begin the development of several instruments to measure LINCOTT variables, and to test several propositions concerning the effects of work-related values held by members of R&D groups on the level of perceived communication problems experienced by the groups when dealing with each other. In several of the propositions the level of task interdependence perceived to exist between the groups was taken into account.

This study was one of a pair in which data were collected from the same set of respondents. The second study was carried out by Richard T. Barth and concerned the effects of "inter-group climate" on communication.

Data for proposition testing was collected in one industrial and nine government R&D laboratories from 284 members of 66 R&D working groups using questionnaires and interviews. Additionally, 54 managers were interviewed.

Ten clusters of work-related values were identified. This was done by subjecting 80 items to a principal components factor analysis with rotation to simple structure. The ten clusters, in rank order, were labeled: Professional and Personal Integrity values; Collegial Growth values; Project Direction or Guidance values; Scientific or Technological Work Fulfillment values; Engineering and Technological Work Performance values; Personal Interaction or Relationship values; Organizational Performance values; Science values; Career values; and "Quick Fix" or Immediate Payoff values. The test-retest reliability for the 80 items was 0.83, with a mean test-retest reliability for the ten scales of 0.77.

The measure of perceived communication problems (PCP) was based on 15 items involving adequacy of current information, time lags in receiving information, and clarity, accuracy and completeness of information received. The inter-item reliability of the scale was 0.82.

Four dimensions of task interdependence, describing the nature of the task relationship between pairs of groups, were measured by 25 items in Douds' questionnaires and 26 items in Barth's questionnaires. These dimensions were Work Initiation and Influence, Input/Output Dependence, Mutual Dependence, and Advisory and Consulting Interdependence. The inter-item reliability for all items was 0.90 and the mean for the scales was 0.76. Discriminant and convergent validity for the four dimensions was demonstrated using the two sources of data in a multitrait-multimethod matrix.

It was hypothesized that the greater the similarity of values, the fewer the perceived problems of communication. The level of task interdependence was included as a parameter, postulating that the lower the level of task interdependence, the less the above effect. Tests were performed at three levels of analysis (individuals, groups, and group pairs) using four methods. All failed to provide support for the hypothesis. This included multiple regression analyses which removed the effects of the four task interdependence dimensions, four types of frequency of contact, and respect for the other group. The latter set of variables was significantly related (at the 0.01 level) to PCP. However, task interdependence taken separately had no effect on PCP.

Two propositions concerned the effect of high or low within-group homogeneity of values on PCP. No effect was found.

Four propositions involved the perceptions of another groups' values as seen by the individual. Data for measures of actual similarity, perceived similarity, and perceptual accuracy were obtained from a "Q-sort" instrument. In it, the respondent rank-ordered 20 work-related value items three different ways. The items were specifically selected for each group pair to minimize bias artifacts. Multiple tests of the propositions were carried out.

It was found, as expected, that the individual will tend to rate values central to himself as desirable in his "ideal associate" (82% responses significant) and for his actual associates (54% responses significant). It was found that the higher the level of respect that an individual has for another group, the more he will tend to perceive the other as holding his own values (significant

at the 0.001 level), and the fewer the communication problems he will tend to perceive (significant at the 0.01 level). The proposition that "the less the actual similarity, the more perceived communication problems will tend to increase with increasing perception of similarity of values," could not be tested for lack of suitable cases. No relationship was found between perceptual accuracy, as scored in this study, and perceived communication problems. (It was also recognized that the measure of perceptual accuracy was not independent of the actual similarity and perceived similarity measures.)

The combined effects of perceived similarity, actual similarity, and perceptual accuracy (as derived from the rank-ordering instrument) on PCP were tested in a multiple regression equation. This replicated the findings above for the separate tests of perceived and actual similarity (at the same levels of significance) and showed that perceptual accuracy was negatively related to perceived communication problems (but only at the 0.10 level). However, this implication that greater perceptual accuracy is associated with increased perception of communication problems is questionable because of the problem noted in the measure of "accuracy" and because of the weak level of significance.

Four case studies are reported which lend credence to the obtained measures of the variables. A posteriori, they also suggest that knowledge of the values important to each group is helpful in understanding the relationship between the groups of a pair. This in turn suggests that one of the many possible reasons for finding no relationship between actual similarity (as measured by the ten work-related value clusters) and perceived communication problems is that the salience as well as the importance of the values must be determined in the particular situation.

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## Chapter 1

### WELL-SPRINGS OF THE STUDY

#### 1.1 - BACKGROUND OF THE STUDY\*

The coupling of the various links in a chain of events from new ideas to products-in-the-field is a major responsibility of R&D managers. In our society, as elsewhere, managers have been solving the organizational problems concomitant with the technical problems one way or another. But repeatedly we hear that there is a great deal of room for improvement. Even though we are able to make the process work, there is not much agreement about what lies behind it--the reasons for its successes and the reasons for its failures. Our understanding of the process, how it works and why it works the way it does, lags behind our ability to make it work.

For a number of years Northwestern University's Program of Research on the Management of Research and Development has been engaged in studies of R&D designed to enhance our understanding of the process. Various aspects have been investigated in a programmatic series of projects carried out by graduate students and staff. These include studies of project selection, centralization vs. decentralization of R&D laboratories, the flow of ideas within the laboratory, the use of operations research and management science, and a number of others (Rubenstein, 1966a). In recent years, several studies have turned attention to various aspects of the information exchange and communication process in R&D; variously termed "liaison," "interface," "coupling," or "technology transfer" to which we apply the acronym LINCOTT.

The activities of the program at Northwestern are part of a field known as Research-on-Research, or  $R^2$ , which has been defined as:

systematic studies of the research and development process for purposes of increasing knowledge about the R&D process and/or as an aid to decision making and policy formation. Included are theoretical, experimental, or empirical work on a variety of such aspects of the R&D process as Organization, Economics, Communication, Decision Making, Personnel, Control, Leadership, and Relation to Environment. (Rubenstein, 1968)

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\* Portions of this section are adapted from material written by the author for Rubenstein, Barth, and Douds, 1969.



The field of Research-on-Research is growing. Sixteen years ago there were half a dozen university groups and a few people in industry and government working in it. In 1968 there were approximately 130 organizations with some 700 investigators active in the field (Rubenstein and Sullivan, 1968). The result of this  $R^2$  activity is to provide a growing body of research knowledge providing an understanding of why the R&D process works the way it does and knowledge that is potentially useful in improving the process.

It is to be noted that analagous to the problem area of this research, which is concerned with communication among technical groups about technical project matters, is the problem of communicating the results of Research on Research to R&D managers. Rubenstein (1963a) notes that "Many poor experiences resulting from bad organizational design and inadequate consideration of some of the ... questions concerning the functioning of organizations can be traced to a lack of interest in, or knowledge about, the methods and content of organization theory," and Research on Research. Thompson (1969) describes several approaches to bridge this gap between knowledge and application.

One form is to train intermediaries, or liaison people, who understand both the  $R^2$  researchers and the managers; these in-house management researchers may also, with attendant problems and advantages, carry out research (Rubenstein, 1964). Another approach takes the form of direct participation by the academic researcher in an industrial organization in the role of a change agent. A third approach is the return of the manager to the university for a brief exposure to academic research, although this is seldom for the purpose, or with the intent, of training the manager as a researcher.

A fourth method, which Thompson is actively developing as described in his paper, is to quickly train engineering managers in the elements of the  $R^2$  process by demonstrating the parallels between it and the scientific and engineering methodologies already familiar to the students.

By nature, the research and development process is a series of linked functions with a roughly sequential flow of work--e.g., research, development, design, engineering, tooling, production, marketing, and use. Within each function there are people with their own specialities, values, objectives, styles of operation, loyalties, interests, and capabilities. The linkage between these functions depends to a large extent upon accommodation between the individuals in the separate functions, especially those that are adjacent in the flow of work--e.g., the researchers, the developers, and the designers--and also those who may not be directly adjacent--e.g., the researchers and marketers.

The Program of Research on the Management of Research and Development at Northwestern has been studying many aspects of this process. The nature of these studies is indicated by the list of project areas it is engaged in:

1. Idea flow in research and development.
2. Control of research and development in decentralized organizations.
3. Strategies for organization and diffusion of research in developing countries.
4. R&D responses to crises.
5. Sources of R&D achievements in electronics since 1945.
6. The acquisition and development of new technical skills in research and development.
7. Integration and utilization of management science activities in organizations.
8. LINCOTT: liaison, interface, coupling, and technology transfer relations between phases of research, development, and application.
9. The information-seeking behavior of researchers.
10. Project selection in R&D.
11. Key researchable problem areas in R&D management.
12. Environmental and management factors influencing the performance of R&D groups.
13. Methodology of research-on-research.

(Annual Report, 1967)

Various aspects of these projects are conceptually and practically inter-related to each other. They all utilize similar approaches in the development of their methodology. We will examine this methodology next. Then the background specific to this study in the LINCOTT area will be described.

## 1.2 - THE RESEARCH PARADIGM

The studies in the Program cover a wide range of topics, theoretical orientations, and types and locations of field sites. They all share a common content in their concern with research and development, its management, or the application of its results in effecting technological change. They also share, more specifically, a common framework in the design and development of their research. The approach is to

1. Draw on the best available knowledge of the subject from the fields of the practitioners and the work of organization and system theorists,
2. To construct propositions that are both plausible in view of the available evidence, and significant in terms of the value of the potential

solutions, and

3. To test these propositions in rigorously designed field studies in operating R&D organizations of industry and government.

This is carried out by structuring the over-all design of a study within a framework that might be called a "research design paradigm.\*" The paradigm is illustrated in Figure 1.2-1 as it is employed by this writer in his work.

The research process begins with a problem, a question. It may be broadly stated, vague, and ill-defined when first encountered. It loosely defines an area of interest. It may be a "social" question (Why is it difficult to establish new R&D industries in some regions?), an "ought to" or "should" question (How should information retrieval systems be designed so that they will be better utilized?), or have any number of other forms. In some sense it defines a research area which broadly establishes the boundaries of the subject matter. In the Program the research area is identified in terms of the project areas listed previously.

There is then an ill-defined path called problem formulation to the next recognizable landmark. It is one that the researcher will likely traverse many times (in either direction) during the research process as he formulates and refines his researchable questions. It is here that the researcher sorts out those parts of the problem that can be based on measurable, empirical data and those that can be based only on judgment, experience, wisdom, and intuition.

There are three criteria for good research questions (Kerlinger, 1965): (a) It should express a relation between two or more variables: Is A related to B? How are A and B related to C? Is A related to B under conditions C and D? (b) The research problem should be stated clearly and unambiguously in question form. A statement of purpose alone is not adequate. The purpose and the problem of a study are not necessarily the same. Questions have the virtue of posing problems directly. (c) The question or problem statement should at least imply the possibility of empirical testing. This is perhaps the most difficult criterion. Many questions are inherently not researchable; and when the question is asked, "So what will this mean if an answer is obtained?," the answer may indicate that some researchable questions are not worth investigating.

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\* "Paradigm. An example, pattern." Webster's Third New International Dictionary, Unabridged. Springfield, Mass.: G. & C. Merriam Company, 1961.



The first two items in the paradigm are illustrated in following sections of this chapter.

Propositions are then formulated to explain the phenomena. The researchable questions and propositions come from several sources: the literature--that of organization theory and other disciplines, prior research results, the managers of R&D, and those in government and elsewhere concerned with R&D policy; from our prior studies; and from the prior professional experience of the individuals in the program. The propositions are linked together, corollaries derived, etc., to build a conceptual model expressing the relationships involved among the variables expressed in the propositions. These steps are carried out for this study in Chapter 3.

The pieces of information needed to measure the variables in various ways are then determined. These are the indicators for the variables that are feasible to collect in the field. Rival hypotheses that offer alternative explanations to the propositions and their measures must also be determined and controlled for in item 3 and all the succeeding ones. Data collection methods--instruments, observations, procedures, etc.--are then designed to obtain the required information and control for the various rival hypotheses. These are described in Chapter 4.

A variety of methods are used to collect the data and to evaluate the propositions, since each method has its own strengths and weaknesses. Interviews and questionnaires are often primary sources of data. Institutional records and other documentation provide other measures. Direct observation and activity time sampling of work are used to provide more direct measures of behavior.

As compared to the "hard" sciences and technology, the state of the art for our "instrumentation" is much less advanced and questions of reliability and validity of the data obtained are greater. Multiple measures and multiple tests are required across a series of studies. With our approach, propositions are tested in the field under a variety of conditions and with a variety of methods, but always subject to the understandable constraints imposed by an operating organization whenever an outside researcher comes in to collect data.

Once the data has been collected, it is examined by various methods of analysis. The indicators are consolidated into scales providing measures of the variables,

their characteristics determined (Chapter 5), and examined in terms of other information collected (Chapter 6). The variables are then utilized in tests of the propositions, which are here performed in Chapter 7, using several techniques and various measures for the variables. These findings are then consolidated in terms of the original propositions and research questions and the process starts anew, exploring new deductions and new insights (Chapter 8).

### 1.3 - PRIOR LINCOTT STUDIES\*

Liaison, coupling, organizational interfaces, and technology transfer, the various LINCOTT phenomena, are all aspects of a related set of complex phenomena having to do with information exchange and communication in the research-to-production process. Of course, these phenomena are not limited to R&D; they are prevalent in various forms in all types of organizations. The phenomena involved are of great interest to organization theorists because of the central importance of communication within and between organizations in understanding organizational behavior. They are of great interest to many practicing managers who recognize that many of their problems lie in this area.

R&D provides a particularly promising area in which the organizational LINCOTT process can be studied. R&D is a dynamic process, chartered to create new ideas for materials, products, and processes. It is committed to inducing change in the organization and in the social system. Particularly in developing military systems, but also in many commercial systems, its products are highly complex, produced on tight time schedules and with constrained budgets. In such circumstances, it is very important that technology be transferred from one organization to another, or from one part of an organization to another, through effective coupling processes. Prompt, accurate, relevant information is required to flow across these interfaces. Clear, organizationally beneficial, timely decisions are required to achieve effective "liaison," "interface," "coupling," or "technology transfer" (LINCOTT) relations.

There also has been increasing attention among mission-oriented R&D-supporting and R&D-performing organizations to specific practical aspects, manifested under various titles such as Technology Utilization, Coupling, and Spin-off. Chief

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\* Adapted from Rubenstein and Douds ( 1969).

among the large federal research and development supporters who have been concerned with these phenomena have been NASA, DOD, NIH, AEC, the British DSIR, and other foreign equivalents, and the various branches of the Department of Commerce that support and/or perform R&D.

Although many of these organizations have expended considerable time and effort in this area, much of this effort has been solution oriented, rather than problem or research oriented. That is, much effort has been expended in trying to find massive quick answers to inadequately defined and understood problems. The prior activities in the Program, as well as the present ones, are research oriented, seeking to understand the phenomena involved. In 1957 Rubenstein (1957) considered the liaison man or group in terms of time, space, and social distance factors as they may affect communication in the R&D laboratory.

Several studies, some from other areas of the program, relate closely to the LINCOTT area. Kegan (1969) studied how a group of radiochemists and related specialists in the life sciences get and use technical information from the literature. It started as an "inside-out" study, in which we were attempting to trace the path of information generated by Argonne National Laboratory into the laboratories of potential users. It soon became evident that such tracing was not feasible within our resources, and the study evolved into an examination of the sources of information and the decisions to use information by a group of people who were one set of potential users of Argonne's output.

For one month, ten researchers in an industrial research and development laboratory recorded a sample of the written technical information items that they received. Four months later they were interviewed to see which of these items had proved useful, and in what ways.

The data showed that a researcher will call an item "useful" even if he does not cite the item, report information from the item, or take some other action based on the information in the item. He will call the item useful when it has had some effect on him or significance for him. Thus, studies that restrict their measures of information usefulness to externally observable behavior may not be validly representing usefulness to the researcher.

Retrospective studies have often had trouble in tracing the sources of ideas or the end use of particular research work. The data of this study indicate that an item may prove useful, not because of the information objectively contained in that item, but because the item causes a cognitive restructuring of the researcher's mind, or a "free association." The item may "release" an idea in the researcher, although another reader without the same stored information or ability may not have the new idea by reading the same item.

In a related study, arrived at from quite a different set of interests, R. Martin (1967) studied the sources of ideas for changes in production processes or products. His sample comprised about two dozen technically based manufacturing companies in the Chicago area--electronics, electromechanical, and mechanical.

His respondents were chief executive, chief engineers, or other executives who are responsible for such changes. He succeeded in getting some coefficients for a model that contains a number of factors which the literature and previous studies indicate have some effect on the decision to accept and use such ideas.

R. C. Mills (1967) analyzed data collected by remote field studies in connection with Phase II of Project Hindsight (Rubenstein, 1966b). He examined questionnaire, interview, and document data relating to the liaison, interface, or coupling relations of a sample of the R&D Event Groups in several large government laboratories (Army, Navy, and Air Force). In addition, he reformulated some earlier models and generated new propositions for test from the results of his study.

Rubenstein, Douds, and Lewis (1967), in cooperation with the RAND Corporation, focused on a very specific interface, the one occurring between systems designers and research and development people--that is, the people in the actual laboratories. Here we were concerned with a number of aspects of the flow of design specifications and requirements, and the return flow of state-of-the-art information between the various groups involved in the planning process as in Figure 1.3-1.

Other studies of a variety of aspects of the LINCOTT process are underway. From this work there has evolved a set of six researchable questions. Each of these larger questions has a number of corollary questions and related propositions as listed below.



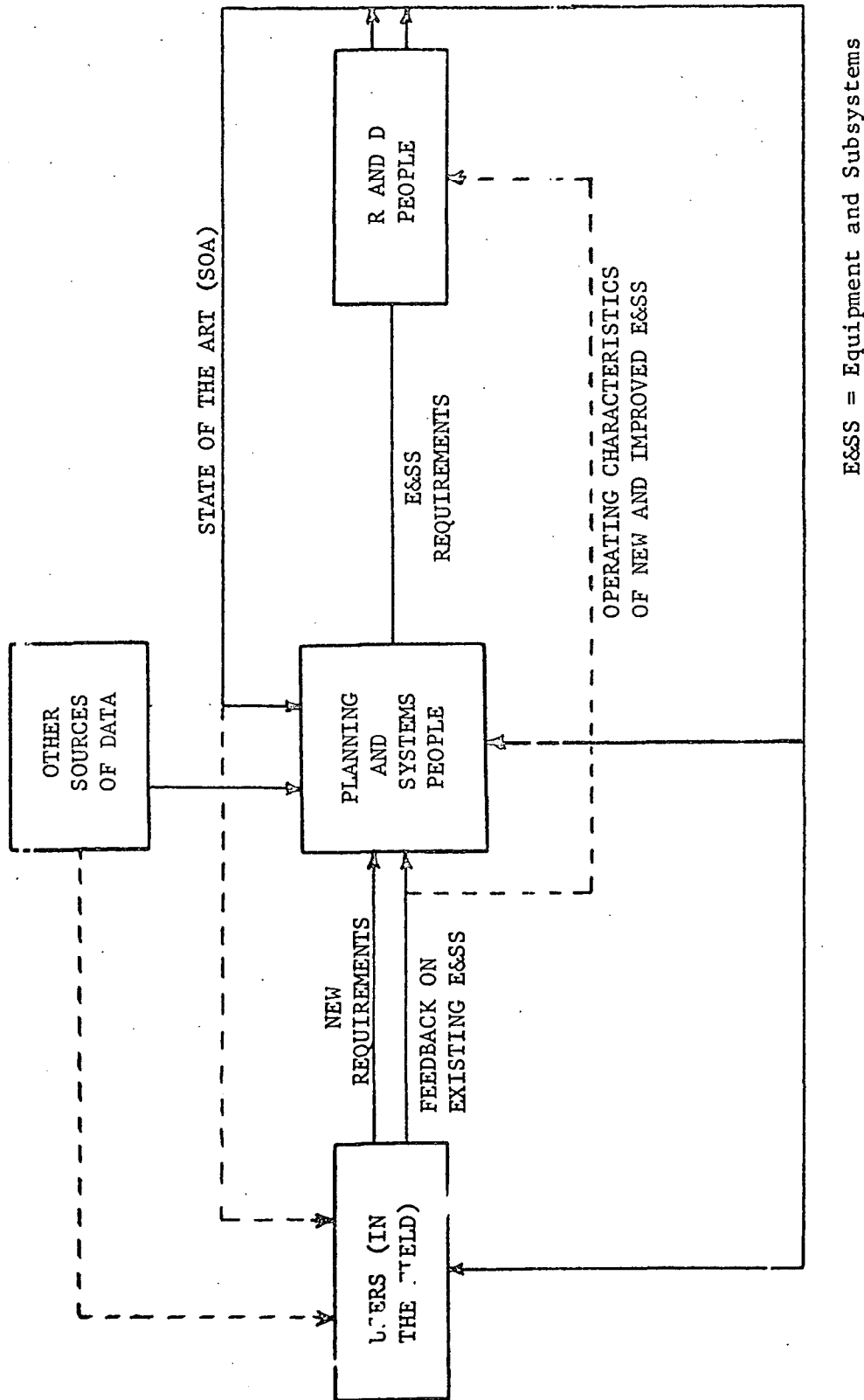


Fig. 1.3-1 - Some Information Flows Among Users, Planning and Systems People, and R&D in Complex Systems

Source: Rubenstein, Douds, and Lewis (1967).

### Need for Formal or Systematically Organized Coupling Between Functional Areas and Organizations

How can communication or coordination gaps be recognized? Is there a threshold of difficulty or conflict above which a formal coupling arrangement is needed? Are communication problems symptomatic of coupling gaps? How does phase of a project affect the need for formal coupling? How much of a gap is tolerable before attempts are required to bridge it formally? Under what circumstances are informal coupling arrangements preferable?

### Nature and Organization of the Coupling Function

Where should such an activity be located? How should skill composition of the activity (group) relate to the nature of the projects and/or groups being coupled? Are different organizational arrangements needed for fire fighting versus longer range coupling? How innovative and how aggressive should the coupling group be in its activities? How "visible" should the coupler be? How large should the group be (from one to many people)? What are the effects of multiple (possibly redundant) coupling channels?

### Measuring the Effectiveness of the Coupling Group or Activity

What criteria can be used? Do formal couplers aid or impede communication? What are the desirable and undesirable side effects of coupling arrangements? How can we identify successful coupling activities and associate organizational design factors with their success? Who should perform the evaluation? How does effectiveness of coupling relate to overall organizational effectiveness?

### Kind of People Needed in Coupling Roles

To what extent do and should managers act as coupling agents? Should couplers be from the groups that are to be coordinated or from other groups--i.e., what are the effects of group loyalties? What kinds of unique training and personality characteristics are needed? How important is the organizational status of coupling agents? Do some individuals have a natural "propensity" for performing coupling activities?

### Effects on the Coupling Activity of Differences in Environmental Conditions

How do coupling requirements and effectiveness relate to organizational and cultural differences--e.g., government versus industrial and U.S. versus international? What environmental factors tend to interfere with coupling--e.g., special languages and styles of operation? How does the nature of the organizational environment affect coupling? How does the emergence of informal couplers depend on the environment? How do coupling problems vary between disciplines and different technological specialties?

### Possibilities of Simulating the Coupling Process

Is it feasible to develop a dynamic simulation of the coupling or technology-transfer process? Would such a simulation (or set of simulations) help in increasing understanding of the process, training people for it, or solving specific coupling problems? Can the dynamics of the process, related to project or program phase, be adequately simulated?

This study is one of a pair in the LINCOTT area investigating the coupling of technical groups within R&D organizations. The general objective of this project is to examine a number of factors that affect coupling and information exchange between pairs of research, development, test, or engineering groups that are dependent upon each other to various degrees. Both studies consider the same set of dependent variables--coupling, communication and information exchange, as conditioned by the extent to which the groups are functionally dependent upon each other. The sets of independent variables, i.e., factors that affect the coupling, are different for each study. This study is concerned with the effects of work-related values of engineers and scientists on communication between working groups. The parallel study was conducted by the author's colleague, Richard T. Barth. Using overlapping data from the same set of respondents, he investigated the effects of intergroup climate on the same dependent variable as illustrated in Figure 1.3-2. The intergroup climate measures reflect aspects of the interpersonal relations, managerial relations and organizationally imposed constraints as perceived by the members of the groups (Barth, 1970).

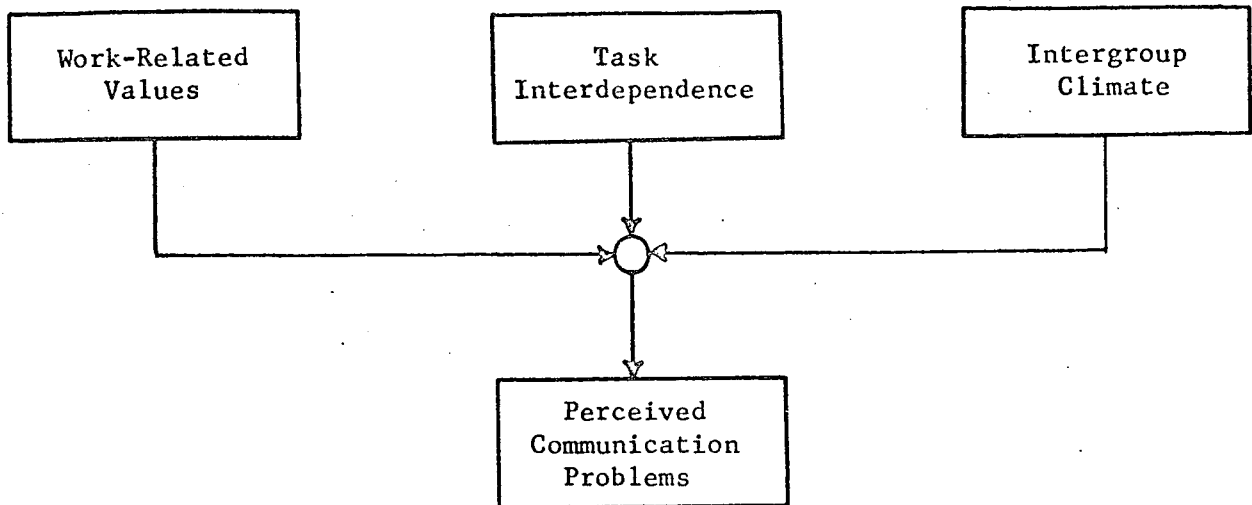


Fig. 1.3-2 - Major Variables of Barth's and Douds' Studies

#### 1.4 - FOCUS OF THIS STUDY--COMMUNICATION AND COUPLING IN R&D

In the next chapter we shall discuss how the general nature of the R&D process may be considered to consist primarily of flows of information in various forms. To a certain extent it is channeled in three streams: science; complex or large-scale technological systems; and industrial or commercial development. There is a considerable amount of interaction among these streams--the results of science and technology find application in other areas from those in which they were originally created. The term "technology transfer" is often applied to such movements of information about new science or new technology that cross organizational or institutional boundaries. Similar movements of information take place within the firm. In the very large organization, the process may be similar to that of transferring science or technology from one type of organization to another.

Projects are created to take particular sets of ideas or objectives and translate them into useful outputs of the R&D organization, marketable products of the industrial firm, or effective technological systems of the government, such as

intra-city transportation systems, air traffic control systems, military offense or defense systems, etc. The technology transfer process may stimulate the initial ideas for these projects or provide solutions to problems encountered during the project. Within the firm, the project is carried out by a variety of groups working on different aspects of it. For these groups to function, much information has to pass back and forth among them. In some cases, most of the information exchange may take place during a limited period when the work goes from one major stage to another--for instance, from development to production engineering. During the work on the major stages, and frequently during the transitions from one stage to another, the work of one group must be coupled to that of another. Information about the specifications they expect to attain, the problems they have identified, methods of solution, test results, costs, delivery dates, and so on, has to be passed back and forth for each to do their own work. Some of this information is passed through managerial channels, some in written form, but a great deal of it occurs as interpersonal communication among the working engineers, scientists, and technicians from their respective working groups.

Communication across the various organizational interfaces among the working groups in the R&D organization provides the coupling links in the flow of work on R&D projects. The output of R&D is information; information is a major input to the process. Creative and adaptive transformations of the information inputs to the output are the substance of the process. It is through the appropriate coupling of the information inputs and outputs of the various groups that the work gets done throughout the process.

This study centers around communication and information exchange among working groups of scientists and engineers. R&D is primarily a process of generating, transforming, and transferring information. A better understanding of the factors influencing the communication process among such people is central to understanding how the process works, to understanding how it is managed, and to improved design of the process.

## 1.5 - RESEARCH AREA AND RESEARCHABLE QUESTIONS

The research area of this study is communication and the exchange of information among task-related groups in research, development, and engineering. There are

a great many factors that affect communication among working groups--geographic, physical, organizational, and individual. Here we are interested in certain aspects that the individual and groups of individuals bring to the situations in which they are communicating with each other; specifically, their work-related values. The values of individuals and of those with whom they are associated are seen as structuring more-or-less stable response predispositions that affect communication process behavior and perceptions.

For this study the initial research questions leading up to the primary research question are: Do work-related values exist for the individual in such a manner that they are discoverable? To what extent are they stable? To what extent are intragroup similarities and stability of values greater than the differences between groups?

Previous research addressing questions such as these indicates that the values of individuals are discoverable, at least some of them are stable, and that shared values do exist or develop within work groups. The similarities, stability, and differences of values within and between groups are less well known. This study provides additional information about this question. Here we seek to relate such similarities and differences to effects on the communication process. The primary researchable question is:

What are the effects of differing work-related values of the members of functionally dependent work groups in R&D on the communication and information exchange process between the groups?

## 1.6 - UTILITY AND POTENTIAL APPLICATIONS

The premise of the study is that the communication process is significantly affected by the predispositions individuals or groups have to evaluate the information they receive, generate, and transmit on certain bases. These bases are evaluative criteria or "values." From a knowledge of these bases and how they are structured by individuals and groups, we then may be able to improve our understanding of why certain groups have difficulty communicating and exchanging information with each other. For groups dealing primarily with information, as is certainly the case in R&D, such difficulties would lead to problems in making decisions and turning out the work for which they are responsible. Knowing some of the important reasons why they have problems exchanging information,

the manager may then be able to ameliorate the difficulty: perhaps directly; perhaps by applying other, more specific information made relevant by the knowledge; or perhaps by setting up a trial change or experiment to test a hypothesis suggested by the explanation.

Conversely, we may be able to predict that certain groups which appear to be communicating well, may not do so when certain types of changes take place in their work situation, such as a crisis or a new project which requires them to work together much more closely than they have done so before.

We may be able to determine general characteristics of people who are most likely to be able to do a good job of communicating well with another group. This would be especially important in those cases where differences of viewpoint between the groups are such that communication is particularly likely to be difficult.

Further, we should be better able to predict when it is likely that such communication difficulties will be prevalent, and so take steps to avoid them by the design of the task and task assignments, by the design of the organization structure, by physical location, by the establishment of certain rules, limitations, or processes directly affecting communication, etc. In particular we may be able to determine when it is desirable for the members of particular pairs of groups to have ready access to each other and when it would be desirable to attempt to limit their contacts with each other.

Further development of this research in follow-on studies may lead to a better understanding of a number of other design problem areas in R&D. The structure and content of work-related values in groups, and their differences among various groups, by way of their effects on information exchange, acceptance, decisions, and subsequent actions, may help to clarify the "not-invented-here" phenomena; may help to explain conflict, cooperation, and work group effectiveness.

## Chapter 2

### THE FUNCTION OF COMMUNICATION AND COUPLING IN THE R&D PROCESS

#### 2.1 - OVERVIEW

This chapter provides an overview of the R&D process. It indicates the ways that communication couples the process together across a variety of interfaces between and within organizations. The context of the various aspects of the R&D process is established--first in terms of the various environments in which the R&D process may be examined, and then in terms of several models describing various aspects of the coupling processes involved in taking an "idea" from its conception to application through the stages of research, development and engineering. In all the stages, information must be exchanged from one group to another--scientific and technological information about new discoveries, new innovations and inventions, and information about needs, requirements and problems, as well as the more usual information of ordinary commerce, government, and management. This chapter, in addition to providing a broad overview of R&D, indicates the nature and relevance of LINCOTT to R&D. In Chapter 3 the propositions specific to this study are developed. The next section is written primarily for the reader not already familiar with R&D.

#### 2.2 - RESEARCH AND DEVELOPMENT IN THE U.S.

##### 2.2.1 - Types of R&D

Very roughly, there are three main streams of research and development which may be distinguished using the terms science, technology, and systems.

The science stream is characterized by the notion of "pure research"--advances in "new" knowledge for the sake of the knowledge alone. The site of such endeavors is characteristically the university and the performer is the "scientist."

The stream of new products and services from industry is the product of technology performed by engineers in their work of developing products from ideas.



With the popularization and increase in status of science, the popular stereotype sometimes has the new products coming directly from the scientists (which is rarely the case). The site of the work is the industrial laboratory.

The stream of systems work is best known for its production of military aircraft, missiles, and space systems. There is growing application of the systems approach to a wide variety of problems--e.g., mass transit, hospitals, and water resources. Systems engineering as an explicit discipline is strongest in the communication, military operations, and space vehicle fields. The site of this activity is the "R&D industry," the complex of government installations and firms devoted almost in their entirety to research and development.

The three terms usefully, but somewhat stereotypically, describe dominant features of the R&D scene in the U.S. today. Research and development is multifaceted and the interactions between these streams are complex. A great deal of research is done in the universities and university-affiliated organizations. Some of the people involved can be usefully described as "scientists" in the sense used above. And some of the work is pure science in the sense of search for knowledge for its own sake. But there are also scientists doing the work in technology and there are those that move back and forth between the areas. In industry there are engineers doing work that is called science and scientists doing engineering.

As with the rest of R&D, the stream of academic research expanded greatly in the 50's and 60's. In terms of the people involved, much research is still accomplished by traditional means, but major changes have taken place in the tools available. Of these, perhaps the most visible in all disciplines is the computer which has made major changes feasible not only in the analysis of data, but in the nature of the data that can be effectively utilized. In physics one finds massive and tremendously expensive instruments--cyclotrons, synchrotrons, zero-gradient accelerators, etc.--that have had major impacts on the conduct of research. Other new devices have had major effects in many fields of science.

Such changes reflect the impact of the introduction of large scale technology into research. In some respects, the organization of science is changing from a "craft" form to an "industrial" form bringing with it new possibilities and new constraints (Swatz, 1966, p. 104).

The stream of research and development in industry is concerned with invention and innovation leading to new products and processes. This is not to say that industry does not perform "pure research." The Bell Telephone Laboratories, for one, have made many such contributions, (Fisk, 1965). There are substantial differences in the level and character of R&D performed among and within industries owing to differences in their scientific base, market structure, established patterns of competition, management character, and so on. But the dominant characteristic is that the firm is engaged in economic competition in the marketing of its products:

An important environmental element affecting scientists in industrial laboratories is the fact that their companies are engaged in continuous commercial competition with other firms. (Hower and Orth, 1963, p. 29)

However, this viewpoint does not represent the whole picture unless particular attention is paid to the words "continuous commercial." Competition exists in science as in industry. Hagstrom (1966) has investigated such competition among scientists, and it is well-illustrated in Watson's (1968) personal account of the discovery of the structure of DNA.

Research and development exists in industry to invent; to feed ideas for new products, or improved ways of producing existing ones, to the production process. A firm may select R&D projects using any one, or several, strategies. Rubenstein provides this classification of over-all strategies which describe the general intent of the R&D program (1963 a, p. 200):

1. Service on current materials, processes, and applications (M,P,A)
2. Minor improvements one at a time on current M, P, A
3. Continual minor improvements on current M, P, A
4. Major improvements on current M, P, A
5. Intentional departures from current M, P, A, one at a time
6. Attempts to meet a future market mission
7. Coverage of a technical field of current interest
8. Coverage of a technical field of potential interest
9. Search for knowledge for its own sake

"Maintenance R&D" includes strategies 1 through 3, "expansion R&D" includes strategies 4 through 6, and "exploratory R&D" includes strategies 7 through 9. All are concerned with invention and innovation.

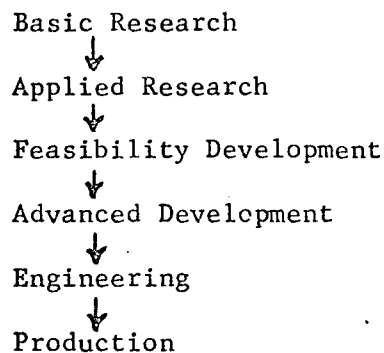
Invention results in a patentable idea and, although in recent years there is evidently an increasing trend not to seek patents, about half of all patents find commercial application (Schmookler, 1966, p. 197). It is much more difficult to account for the amount and importance of innovation in industry. The "formal" R&D segment of industry is primarily concerned with both, but the process of transforming the ideas of its output to practice requires a great deal of innovation elsewhere--not only in production, but also in sales, advertising, management, etc. In the manufacturing sector of the economy R&D costs are roughly about 2% of net sales. While specific figures are essentially impossible to obtain from standard data sources, those available from their own firms to the blue ribbon panel that prepared the Department of Commerce report: Technological Innovation: It's Environment and Management, 1967, indicate that R&D represents about 10% of the cost of the total innovative effort involved in introducing a successful item. Some of the difficulties that can arise when development work is performed outside of the development laboratory are recorded in a case study by Ronken and Lawrence (1952).

The third major stream of research and development is both the largest and the newest. It contains the R&D industry that has grown to meet the demands of first, the military, and later the space program, for complex systems. It is largely concerned with aerospace and electronics systems. Another segment is concerned with nuclear applications. This industry has developed almost entirely since the second World War. Its primary characteristic is that its product is R&D per se. Ideas are bought and sold. Of course, it has a variety of products on the market and production lines do exist in the R&D industry. The products are often characterized by high technological content and a short time span to obsolescence. It is not uncommon for "production" to consist of 100 items or less, be it for a multi-million dollar radar or aircraft or a \$5,000 instrument. Generally, it is only the components--transistors, hydraulic actuators, etc.--that reach production levels characteristic of the rest of industry. The hardware products of the industry are generally systems or subsystems of larger systems. A significant portion of the industry's output is reports. In dollars the quantity of this output is not large; in part, because a study project does not require the magnitude of capital equipment or supporting staff that hardware development does. But the impact of such studies is of an entirely different order. No figures can be quoted on this topic

because it is still a largely untouched field of inquiry containing severe measurement problems.\*

One of the more remarkable aspects of the R&D industry is the manner in which it seemingly "invents on schedule." Contracts for the development of new systems place the performer under the obligation to produce a new contribution to technology at a specific time in the future. In large measure the industry succeeds in doing this. But it is not surprising that it frequently has difficulties with cost and time over-runs. In part, this may arise from the competition among firms for contracts, as well as from the technological uncertainties involved. This difficulty also exists within the commercial firm where R&D is not done on a contract basis.

The process of transforming new scientific knowledge into marketable items is often viewed as a movement from research to development to production. These stages are broken down in a variety of ways by various writers, such as:



To a certain extent this conceptualization does fit the process, but it is more idealized than descriptive. One will find in industry many groups or departments bearing titles similar to the above, implying an orderly flow of R&D activities in the firm. The difficulty is that the flow is not so orderly, it does not appear to actually occur in the sequence implied by this model.

One of the more common problems of R&D managers is concerned with coupling their research work to development, whether their "research" be "high" (state-of-

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\* Measurement techniques in this area are being developed as a part of the Idea Flow studies of the Program of Research on the Management of Research and Development, Northwestern University (Siegman, Baker, and Rubenstein, 1966; Baker, Siegman and Rubenstein, 1967). Sources of "breakthroughs" are the subject of the Department of Defense study: Project HINDSIGHT (Sherwin and Isenson, 1967). A similar study has been carried out by the Air Force (Price, et al, 1966).

the-art) science or "low" (well known, but new-to-the-firm) science. Jack Morton, who heads components research and engineering at Bell Labs, describes the process used in his organization in terms of a systems approach (1964):

The systems approach is nothing more than a direct steal from the scientific method: You begin with a statement of objectives ... then proceed through succeeding steps to the experiment. When applied to the management of a research organization, the systems approach becomes a "people system" for the processing of information. Sometimes the flow of information should be encouraged; at other times it should be inhibited. Hence, the people system must contain both bonds, to facilitate the information flow, and barriers, to limit it.

There is often a major break between "research" and "development," i.e., between "science" and "technology," even in firms large enough to be able to support basic research as well as development projects. Marquis and Allen (1966) investigated the relation between science and technology by examining information flows of documentation. Combining their results with those of several other investigators, they found support for the hypothesis of the independent growth of science and technology. That is, the flow of information from research to development is not as linear and rational as implied in the model on the previous page. However,

(T)here does exist in certain circumstances a communication link between the two activities. Furthermore, given these circumstances, the communication is bilateral, direct, and quite rapid. Second, the degree to which specific technologies advance independently of the science underlying them is variable. Some technologies are more closely coupled than others to their science.

This coupling may occur as a "cultural" factor specific to the technology, such as the relation between the transistor technologists and the solid state physicists appears to be, or it may be specific to the organization.

Project HINDSIGHT (Sherwin and Isensen, 1967) provides similar results indicating that the relation between key "events" in the development of military systems and the scientific discoveries that lay behind these events was tenuous and involved long time lags.

### 2.2.2 - Some Common Characteristics of R&D

While we can roughly distinguish three "streams," or broad areas of R&D activity, the organizations in each have a number of commonly shared problems and share some basic characteristics.

Rubenstein, (1966a) summarizing 10 years of programmatic research-on-research, lists seven key concepts commonly arising in the several hundred organizations studied. These are:

1. Gaps in the diffusion of ideas and information.
2. Dynamic and ad hoc nature of objectives for R&D.
3. Operational criteria for R&D.
4. The role of interpersonal relations.
5. The key man.
6. Minimum effective size.
7. Risk, subjective probability, and estimating.

Coupling and the communication of information across organizational interfaces is a central part of the first:

#### Gaps in the diffusion of ideas and information--

This phenomena is known by various names in the R&D field, such as, "interface," "liaison," "transition," and "diffusion." It is a critical aspect of all discontinuities in the R&D process where different groups and organizations must transfer information. Our findings so far, contrary to much of the wisdom literature, indicate that this problem area exists not simply or even primarily because of the lack of communication media or of clever ways of exchanging information.

Some of the reasons for difficulties in this area appear to be:

1. Preoccupation of specialists with their own problems
  2. Distrust of other specialties and functions
  3. Lack of motivation to accept or participate in innovation
  4. Avoidance of risk
  5. Lack of common conceptual frameworks and languages.
- (Rubenstein, 1966a)

R&D organizations also share some basic characteristics. We shall note three. The first of these characteristics is that R&D is involved in the creation of "new" knowledge. Whether one is talking about the R&D industry--which is primarily oriented towards military and space systems--or about the R&D performed

in the manufacturing sector of the economy, this characteristic predominates. The new information may manifest itself as a radar, a missile, or a computer, but almost by definition, at the time the system, process, or component was desired, it did not exist. When a concept becomes a reality as a new product or process, new information has been created and applied to the transformation of materials.

A second common characteristic of R&D is that it is organized--"chartered"--to create such "new" information and to find new ways to apply "old" information in the creation of new materials, processes, and products. In a deliberate manner it seeks to create technological changes; changes which affect the economy and the society as the products of R&D eventually enter the marketplace or find utilization in various systems.

Of all functions in most major industrial organizations, research and development operates as one of the major innovating systems. Whether it be for product improvement, customer service, new products and processes or more basic inquiry, the R and D laboratory, in part at least, operates as an impetus for change.

(Siegman, Baker, and Rubenstein, 1966)

This second characteristic of industrial and governmental R&D contrasts somewhat with the so-called "pure science" orientation typified by the academic research stereotype. Such research is oriented towards the acquisition of new knowledge, but the activity goal does not include the transformation of the knowledge in the direction of application in the society--at least in the pure stereotype. That the stereotype has some basis in behavior creates problems in R&D. Industrial R&D managers discuss the differences in dealing with "scientists" and "engineers" (e.g., Reiss and Balderston, 1966; Blood, 1963), and it has been researched (Danielson, 1960; Marcson, 1960).

A third characteristic of research and development, and in particular R&D as an industry, is its dependence upon highly trained, uniquely skilled manpower. This characteristic, while not surprising when stated so simply, manifests itself in many ways which are only beginning to be explored by researchers on research.

People, facilities and "knowledge" are key resources of all research and development communities. Of the three, people are the most significant and critical resource. People are necessary to design, construct, modify and operate facilities. People are the main instrument for the production, transmission and retrieval of "knowledge." Economic wealth makes it possible to recruit, hire, develop, and support these people

and to purchase facilities. Undeniably, a set of objectives or purposes is also important, and a good "reputation" makes it easier to attract personnel. Because organizational factors may have major effects on human productivity and greatly affect the utilization of human endeavor, the complete understanding of human organization, and especially of the complex R and D organization, will ultimately require the integration and understanding of all the aforementioned factors and many others. (Rath, 1966, p. 1)

One of the more unexpected aspects of this factor is its involvement in the continuing resistance of the R&D industry to geographic dispersal despite considerable government interest in this problem and massive doses of government funds aimed at encouraging the growth of new R&D geographic complexes.

The question is one of degree rather than dichotomy. Other industries may aggregate because of the availability of raw materials, transportation, market, or finance factors. And certainly the availability of skilled manpower can be a significant influence in other industries. But it would appear that many sectors of the R&D industry, such as electronics, could readily be located anywhere in the nation. The basic input to the industry is knowledge--a readily relocatable item, whether contained in books, reports, or men's heads--but yet the industry has proven to be not readily relocated.

There are at least three basic points characterizing R&D: 1) The creation of "new" information is its central concern, whether the information is new to the individual, the firm, or mankind. 2) It actively seeks change by transforming this information into new products and processes. 3) It is dependent upon highly trained, uniquely skilled manpower.

In this section we have seen that a primary resource for R&D is information, in addition to men, money, and equipment. R&D functions through a variety of information generating, transmitting, and transforming processes that lead to new technology and new materials, products, or processes. The relation of men to this information transmission and transformation process is crucial to understanding it, as will become apparent in the following discussion.



### 2.2.3 - Studies of the Individual in R&D

Much of the literature in organization theory pertaining to R&D concerns the individual and the factors affecting his behavior. Less attention has been paid to the problem-solving behavior of individuals in R&D. We shall consider briefly some psychological, sociological, and design behavior studies.

Studies of the individual in the organization are often concerned with his affective states and the reward structure of the organization. For instance, Friedlander (1965), to choose one example from a very large literature, surveyed approximately 2000 scientists in one R&D lab to determine the relationship between the importance and satisfaction with 73 environmental factors. His primary finding was that factors of extreme satisfaction are significantly more important than factors of mild satisfaction or dissatisfaction.

One of the larger studies in this area concerned engineers and scientists in eleven different laboratories in industry, government, and universities. The primary factors studied in relation to individual performance were (Pelz and Andrews, 1966):

- Freedom
- Communication
- Diversity of specialties
- Dedication
- Motivations
- Satisfaction
- Similarity to colleagues
- Creativity
- Age
- Coordination and autonomy
- Groups

Factors such as the above, and others closely related to them, are a part of the "social" environment of the individual. Marquis (1965, p. 28), commenting on the problems of selecting personnel for R&D, notes that the amount of education, creativity, degree of science orientation, and age account for about 30 to 35% of the variance in productivity and therefore recommends that major attention be given to providing challenging work, adequate resources, and discriminating recognition of excellence.

The relation of the individual scientist or engineer to his task is less often studied. It is illuminating to note the introspective observations of the Nobel-Laureates (cf. Szent-Gyorgyi, 1966; Feynman, 1966). It is possible that their

outstanding achievements are due solely to superior intellect; it is likely that their processes of thinking are different than those of the ordinary scientist or engineer; it is possible that those processes are learnable.

While the Nobel-Laureates create knowledge new to mankind, and invention in R&D also does the same, innovation--also a major activity of R&D--involves the creation of "new" ideas in a more limited sense:

An innovation is an idea perceived as new by the individual. It really matters little, as far as human behavior is concerned, whether or not an idea is "objectively" new as measured by the amount of time elapsed since its first use or discovery. It is the newness of the idea to the individual that determines his reaction to it. . . (Rogers, 1962)

The design process of engineering has been the subject of as much speculative writing as the process of management. Only recently has it become the subject of behavioral research. Many of these approaches view design as a rational process (cf. Jones and Thorniley, 1963). However, behavioral research has been conducted by Marples (1961), and Ranström and Rherman (1965). Mitroff (1967) employed a unique method for studying design behavior. He simulated a portion of an engineer's design process and developed his analysis in terms of observations of the reaction of an engineer and the engineer's client to the simulation. His conclusion is that the design process cannot be adequately treated in terms of the technical characteristics of the design problem. "Every design variable has both a behavioral as well as a technical meaning," (1967, p. 246). The coupling between the engineer and his client is an integral part of the individual engineer's design process, according to this research.

Marples (1961) studied the relation of the individual to the problem-solving design process. The design problem--to create an item that meets certain specifications within a set of constraints--is treated as a decision tree which may be explored in depth (serially) or in parallel. Critical decisions are made by evaluating proposals against a set of criteria derived from underlying values. If the criteria are themselves not clearly defined, then one of the subproblems of the tree is the search for relevant criteria. Marples groups the values that lead to these criteria under three headings: 1) engineering values that reflect the properties of materials and the laws of nature; 2) administrative values reflecting the importance of time, cost, space, and manpower; and 3) abstract values pertaining to society and the individual designer. The criteria are

derived from some weighting of basic engineering, administrative and abstract values. These criteria determine the critical decisions, which in turn determine the path through the design tree to the final design.

Figure 2.2-1 summarizes the information flow relations. Inputs to the designer are the problem specifications and constraints (which may change as the design effort progresses), his a priori knowledge of the field and the organization, and current technical information.\* Outputs of the process are redefinitions and refinement of the problem, technical information made available to others, and the final design.

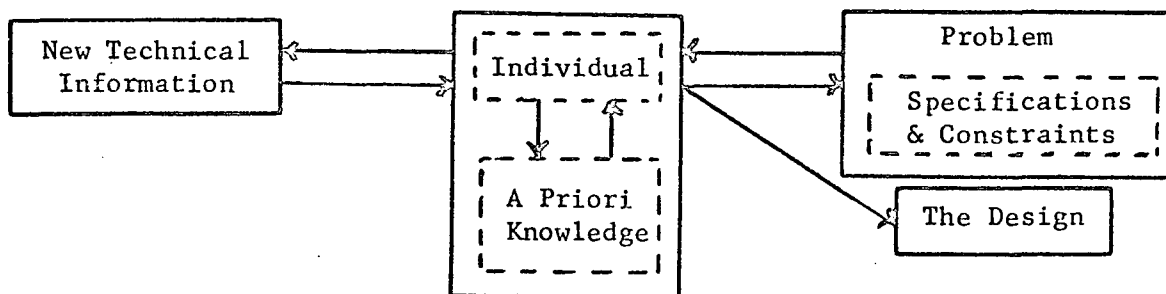


Fig. 2.2-1 - Information Flow Relations

Such studies as these and theoretical approaches such as those of Shelly (1964) and Good (1964) raise important questions about the information-seeking behavior and the information environment of the scientist and engineer. Again, there have been many "rational" approaches to the problem of information retrieval. (cf. Lipitz, 1966). The behavioral aspects of information search and acquisition behavior by individuals in the research and development environment have recently come under study (Rath, 1965; Werner, 1965; 1969; Marquis and Allen, 1966; Mullins, 1967; Moor, 1969).

The scientist in particular, and sometimes the engineer, has been characterized in studies of R&D as having a "local" or "cosmopolitan" (Merton, 1957) or "professional-organizational" or "specialist-institutionalist" orientation. The cosmopolitans are seen as oriented towards their professional peers and

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\* Following Thompson (1956).

ideology independent of the organization, and conversely for the locals. Hower and Orth describe these differences in terms of basic assumptions about the "management culture" and the "scientific culture:"

In general the management culture may be said to place a high value upon financial soundness; hierarchical authority; loyalty to the company; conformance with established policies and procedures; growth in business volume and in size of the organization; "getting action;" "getting ahead;" and tangible private rewards (promotion and increased pay) for superior performance.

(W)e can postulate that, possibly by innate disposition and certainly by education, the scientist is motivated to strive to add to his own and the world's store of knowledge. Even more important for our purposes, he is trained in "organized scepticism"--to think independently, to suspend judgement until adequate data are at hand, to refrain from making claims until they can be substantiated, to accept the scrutiny of fellow scientists as a part of the verification process (as well as being a means of obtaining recognition), to demand of himself and others rigorous logic and the greatest possible objectivity in the course of his work, and to submit to the authority of established scientific criteria and technical competence rather than the authority of hierarchical position.

(Hower and Orth, 1963, pp. 34-7)

However, it does not appear that the dichotomous view of the orientation of the researcher to his environment holds up empirically. Goldberg, Baker, and Rubenstein (1965 ) review the literature containing this view and contrast it with several field studies including their own. They find that the R&D personnel "did not choose between organizational and professional rewards, as has been suggested by the literature, but that they varied in the extent to which they sought after personal gratifications in general, whether these came from the organization or the profession." Further evidence of the actual behavior of scientists in contrast to the ideals of science, with important implications for the flow of information, is given by Hagstrom (1966) who finds that:

Competition for priority is one of the central facts of life for the scientist. . .

This concern [about being anticipated] motivates them to work hard and fast, but it also leads some of them to withhold information from their colleagues until they are ready to publish.

There are good reasons to believe that allowing scientists freedom to select their own research problems, influenced as they are by a desire to make discoveries their colleagues will find important, is an effective way to allocate human effort in basic research. Giving scientists freedom to

compete has consequences that limit the effectiveness of science, but its major consequences are to facilitate discovery and the dissemination of discovery.

In these various studies we find the environment for the individual in research and development being studied from the standpoint of its reward structure, which may be a combination of rewards available in the immediate group, the larger organization, and the community of peers; from the standpoint of the task information flows; and from the standpoint of the technological skills involved.

#### 2.2.4 - Studies of Working Groups in R&D

From the standpoint of R&D management, in most organizations it would appear that the basic conceptual building block for the performance of work is the small group rather than the individual. This is not to say that individuals or "key men" are unimportant, but it appears that in order to effectively carry out much of the work, it is best performed by groups rather than individuals. In part, this arises because of the interdependencies created by the technological problems. In contrast, much of the work of researchers on R&D is on the individual as noted above.

Small groups have been studied extensively in the experimental laboratories of behavioral scientists. Collins and Guetzkow (1964) have summarized much of this literature with respect to decision making. However, it is difficult to translate this laboratory work to the field. " . . . one may not extrapolate these laboratory findings too quickly to organizations in general," (Guetzkow, 1965, p. 548). Perhaps this is true in part because of the commitment of the group members to their career, effects of the environment, and the multiple group memberships possible for the individual in the organization.

Eyring (1966) investigated the effects of uncertainty on several task groups in the aerospace industry. A partial representation of the structure involved is given in Figure 2.2-1. Not shown are the functional department ties existing for each group. With respect to a given project, project decisions with respect to technical specifications, time deadlines, and budgets constitute inputs to the groups. Outputs from the groups are oral and written progress reports containing task decisions and technical results. Considerable information also

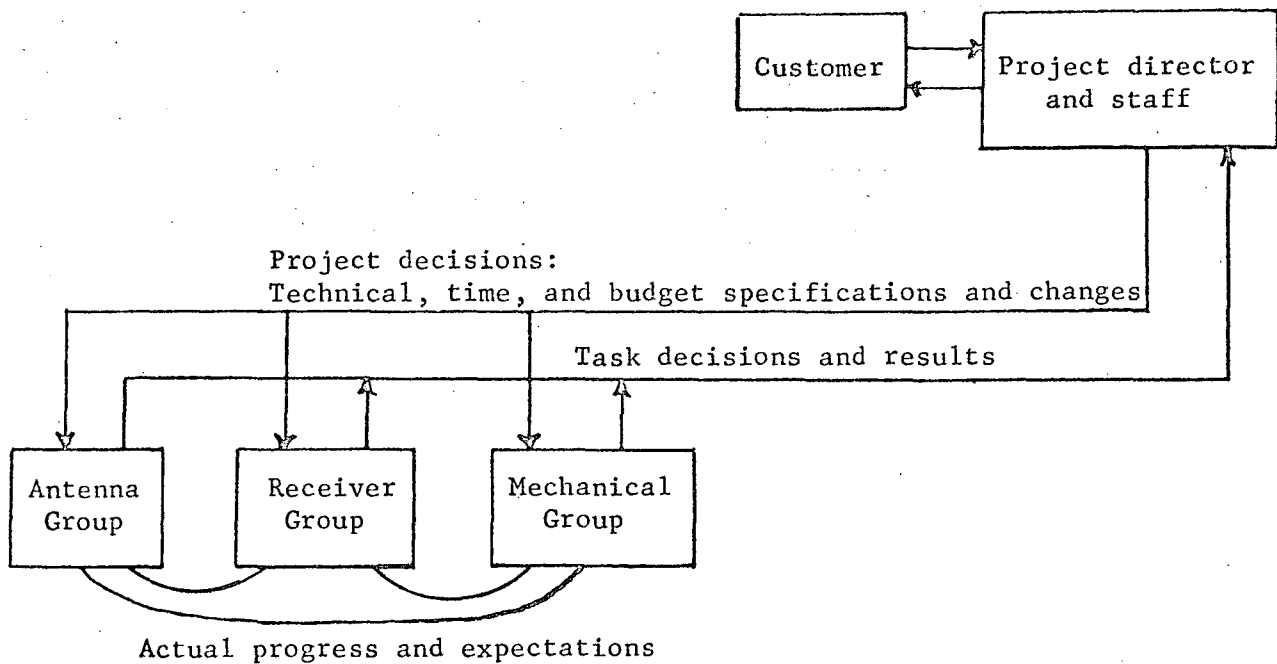


Fig. 2.2-2 - A Partial Representation of the Effects of Uncertainty on Several Task Groups

moves between the groups including anticipated decisions and technical results. Changes in decisions occur more or less continually as problems are further defined and tests performed. Some of these result from partial or delayed inputs to the project director relative to information received from other groups. The task solutions arrived at in any one group cannot be determined on the basis of technical specifications they are initially given, for these never fully define the problem.

The effects of uncertainty in the task information environment include:

The unknown difficulty of a design problem, assuming fixed specifications, is a major source of uncertainty. . . The possibility that specifications may change is a source of uncertainty for group leaders. [These may arise from] insoluble problems encountered by other design groups. Project management may decide that a trade-off of specifications between groups will be more desirable in matching the problems with the technical resources of the groups. The customer's objectives may be reassessed. . . . Formal changes in technical specifications tend to be anticipated by group leaders, who informally redefine their design problems by setting new technical goals for their groups. . . . Information is solicited between group leaders in an attempt to predict changes in specifications, but they tend not to communicate their own informal changes, in order to avoid criticism for noncompliance with official goals.

(Eyring, 1966, p. 173.)

Barnes' (1960) study centered upon groups of engineers in two industrial organizations. As is true in most of research and development, the technology involved creates a strong interdependence among the individual engineers and their groups. His study stresses the importance of understanding productivity and performance as parts of complex system of elements arising from group phenomena. He treats patterns of organizational constraints--the organizational system, in part--as an independent variable, with group and individual development, performance, and satisfaction as dependent variables. He compared two groups performing similar tasks in two different types of organization systems and characterized the system as relatively "open" and "closed" in relation to the kinds and degrees of constraints acting on the groups in the different settings.

Burns and Stalker (1961; also Burns, 1961) report a similar study with similar results found in a number of firms. The "open" versus "closed" structure is not treated as "good" or "bad" by them, but rather as reflecting a continuum related to the rate of change in the organization's environment. In these studies the authors find the organization with the more open structure, as reflected in the flexibility of the communication network and the range of topics admissible to discussion, are able to more quickly adapt to environmental changes.

Steade (1966) presents a brief study of the transitions between various stages of research and development. It is often difficult to transfer the work on the development of a new product from one group to another in the research and development process. Coupling problems tend to be more severe at these points. He studied a situation in which individuals or groups, in part, moved with a new item from applied research into development and production.

Weiss (1956) reports the analysis of data collected under Jacobson and Seashore (1951) in a government agency administering research contracts. He presents a comparison of the actual organization structure as determined from the communication network which shows marked differences from the formal organization chart. This reveals the key roles that a limited number of individuals play as liaison agents in linking the communications among various groups.

In the study of relations among groups we find two related problem areas. One is concerned with the "vertical" aspects of the organization. These are often-times expressed as problems of hierarchy and management control, but particularly in the study of research and development it appears that such concepts--in the sense of "chain of command" and "bureaucratic control" in contrast to "task control" system--are severely limited. Indeed, Pugh, et al, (1969) in a study of 52 diverse work organizations found that such concepts do not necessarily apply in a variety of situations. In R&D this "vertical" dimension of the organization is concerned with such problems as the initiation of projects within groups, reporting of progress and problems, changes in task, time, and budget specifications, provision and utilization of techniques, and redirection of effort towards the given or new task objective.

The second area is concerned with the "horizontal" dimension--the relations among groups in the workflow or groups that have information pertinent to decision making in the workflow. Such problems are not considered in the Weberian concept of bureaucracy and are not adequately explained in the "human relations" approach. Three levels of horizontal coupling may be readily distinguished: a minimal, "loose" coupling such as might exist between marketing and R&D; a tighter linkage through one or two "liaison agents;" and a close coupling through relatively frequent interactions among a variety of people in two or more groups (Douds, 1967). Rubenstein (1957 ) presents a framework for a number of the environmental factors creating barriers to communication between groups. These types of situations are sometimes termed "interfaces" among groups. Some models of the interfaces in R&D and the communications across them that couple groups together are presented later in this chapter.

There have been a variety of structures evolved for managing R&D projects, particularly in the governmental-aerospace industry. Similar problems of organization structure arise in the manufacturing industry, especially when complex systems are being developed. This is particularly true of the process industries, such as chemicals, or those whose product involves a large physical plant, such as in nuclear power and communications. The numerous cross-ties that give rise to "vertical," "horizontal," and "diagonal" communication may arise directly from the nature of the task and the technology involved. When R&D is done on contract there is a specific end-item to be produced. The customer initially sets certain specifications as goals or requirements. However, due to the nature of systems--technical as well as social--a change in a



variable at one point in the system may have severe effects upon some remote part of the system. Initially, specifications are set for the various system components that have to be developed but, as indicated in the discussion of Eyring's study (1966) there are frequent changes in expectations, attainments, and the specifications themselves. One consequence of this is that there are many relationships that are developed between various groups that are required on a systemic basis to handle the decision and information exchange problems involved. Experience has shown that these cannot be handled in a strictly hierarchical manner. The expertise of the groups involved is necessary, both from the standpoint of specialization and current awareness of detail. Direct coupling of the working groups is usually required.

These properties of the R&D process have resulted in various types of organizational configurations. Terms used to describe them are: "functional," "project," and "matrix" or "overlay" organization structures. Various characteristics of these structural configurations for R&D have been described by Hertz and Rubenstein (1953), Shepard (1956), Bowie (1957), Chipp (1961), Welsh (1961), Davis (1962), Kurkjian (1963), Lazar and Kellner (1964), Cleland (1966), and Steiner and Ryan (1968).

In practice it is often difficult to determine the actual nature of the form of organization because of the many variations made by managers in adapting to their particular situation. The functional type is characterized by working groups aggregated on the basis of function, training, or specialization. This enhances the coupling of groups with similar background experiences, skills, and information, but tends to make coupling of groups from different areas working on the same project more difficult. In the project type of organization, groups are formed as needed to handle specific projects and, theoretically, disbanded at the end of the project. This form enhances the coupling among the project groups, but increases the problems in coupling the functionally similar groups. One group may attempt to solve a problem that another group has already solved, new developments in their fields may not be disseminated, and so on. In the matrix form of organization, individuals or groups have a "home base" in functional departments and separate project offices are set up for specific contracts or projects. The individual project tasks are assigned to groups in the functional units with the project office remaining responsible for technical decisions and usually for the expenditure of project funds. In theory, the coupling between the various working groups is maintained through the project office. It

has not been shown by research studies that there is any simple relation between the form of organization and the effectiveness of coupling.

### 2.3 - SOME CONCEPTUAL MODELS OF COMMUNICATION ACROSS R&D ORGANIZATIONAL "INTERFACES"\*

#### 2.3.1 - Interface and Liaison

The research and development process begins with needs, ideas, or problems and eventually results in new knowledge and useful operational techniques, equipment, or systems. Between the origins of an idea or requirement and its practical application at the conclusion of a project, many individuals and a number of groups may work on various aspects of it as it proceeds through various stages of development. At the points where information is passed from one group to another, an "interface" may be said to exist between the groups.

Just as the term "interface" is used to describe the technical specifications required to match two pieces of equipment so that together they can perform their intended functions in a system, so "interface" may be used to describe the necessary exchange of information between organizational groups developing these pieces of equipment so that the groups may function together in the overall R and D program.

As work on an idea proceeds in a project or a series of projects significant transitions often occur as it moves from one group to another, from research, where the basic concept may be established, to development, where "practical" technological feasibility may be demonstrated, to engineering, where it is readied for commercial production.

Each of these transitions involves interfaces. Depending upon the particular situation, there may be few or many such transitions. In general, "transition" in the R and D process refers to the movement of a body of work from one group of workers to others as the ideas progress from one stage to the next. The body of work may consist of ideas, theories, procedures, know-how, and other forms of knowledge, as well as drawings, models, tools, and other physically real materials.

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\* Adapted from Douds and Rubenstein, 1966.

Some of the stages will involve the transfer of the project from one organization to another, or from one organizational unit to another. Other transitions will not involve such a transfer. They may involve a higher management decision to determine whether investment in the project will continue, with continuation involving essentially the same group of individuals (Steade, 1966). If the transition involves more than one organizational unit, an interface may be said to exist, where there may be conflict or communication difficulties. Such transition interfaces may exist in the flow of work on a program or project between government agencies, between an agency and a contractor, between research and advanced development groups, or between R&D and production, etc.

Interfaces may also exist between groups simultaneously working on the same project, either in comparable or different stages. Such coordination interface situations involving distinct organizational units are particularly common in the aerospace industry and in the military laboratory/industrial contractor relationship. For our present purposes, "interface" is taken to focus on communication problems arising from functional differences between organizational units, specifically excluding intra-group communication and "upward" communication with management.

Potential or actual communication and conflict problems existing at an interface between organizations may constitute a threat to the success of a project, either in terms of the conceptual or physical results desired or the economic constraints imposed. Methods for diminishing or circumventing the communication and conflict problems are required. One approach is to reduce the necessity for communication by advanced planning, full documentation, etc. While this may reduce the number or severity of the problems, it also may create interfaces at other points in the organization.

One of the common methods of attempting to solve such problems creates a liaison function and very often a liaison role for one or more individuals (Rubenstein, 1957; Burns, 1961). This may appear in a wide variety of forms: from a single individual to a relatively large number; in a strictly informal to a highly formalized manner; on a "catch-'em-when-you-can" to a full-time basis. The liaison role may appear as a component in a wide variety of strategies for bridging the interface communications gap.

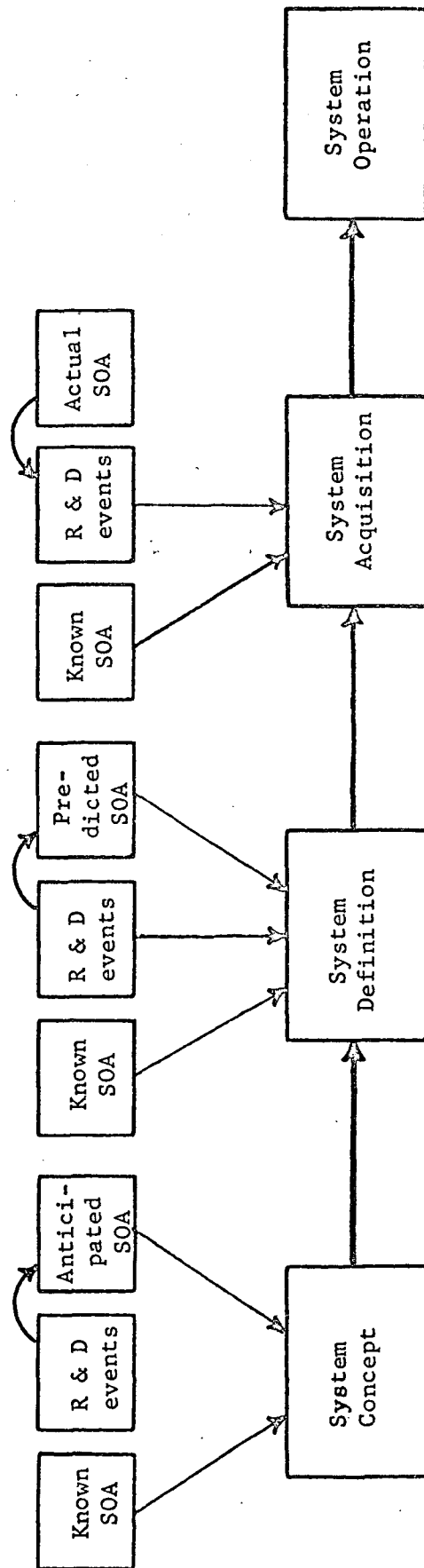
### 2.3.2 - System Sequence Flow

A definite sequence of activities is involved in bringing a new system into being. (This same sequence applies generally to subsystems and specific items of equipment as well. The following discussion will be in terms of "systems," but the words "subsystem" or "component" can be substituted. It can also be applied to software.) Figure 2.3-1 describes four major steps in the process: Conceptualization, Definition, Acquisition, and Operation. These are shown as distinct steps, but in practice, there is considerable overlap and feedback. Since the terms system, subsystem, equipment or component can be substituted for one another, the model also nests within itself. Each of these nestings creates the opportunity and the need for information exchange between various organizations and their elements. The role of interfaces established among various organizations and their elements is vitally important.

In each phase there is a complex interaction among those primarily engaged in doing the actual technology development, those responsible for planning and guiding the development of the system, and the users. These were indicated in over-simplified form in Figure 1.3-1. In the initial stage of the systems sequence (Figure 2.3-1), given a concept for a system and knowledge of existing science and engineering state of the art (techniques, know-how, etc.), the concept is "sold" technically on the basis of what the anticipated state of the art will be when the system becomes operational. As indicated in the figure, the anticipated state of the art is based upon knowledge of existing R&D events, whatever their source may be. The skill of the personnel in making these estimates of future state of the art is critical to the success of the program.

In the Definition stage, R&D events may feed directly into the definition process. If the final entity is not unduly complex, or if cost constraints are not restrictive, this and the known technology may be sufficient to define the objective. This is usually not the case, so accurate predictions of the state of the art must be made if the program is to have a minimum number of contract modifications, meet its schedule, meet its budget, etc.--that is, to be highly successful. Such predictions will be based upon data coming from R&D events either within the program or external to it.

In the Acquisition or reduction-to-practice stage, all knowledge must actually exist when the system becomes operational. R&D events utilized in the final



SOA = State of the Art

Fig. 2.3-1 - Major Interfaces and Inputs in the Systems Sequence

Source: Douds and Rubenstein (1966)

entity are all within the actual state of the art.

Interfaces may occur at almost any point in the process--from those contacts that stimulate initial ideas or suggest problems in need of solution, to the final hand-over of an item to a customer. Some of the common points in the R&D process, as indicated in Figure 2.3-2, where liaison efforts may be required to couple the activities of two organizations or two groups include:

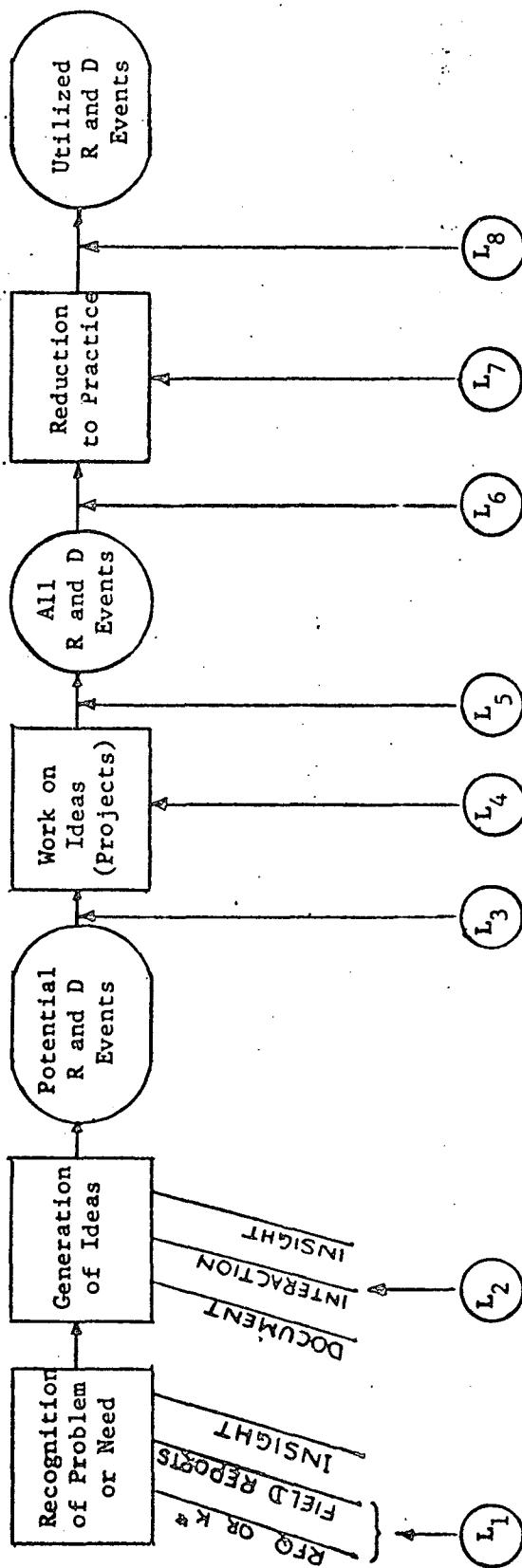
- L1: A liaison activity may be introduced at the interface between the R&D group and the user of the R&D output or intermediate outputs to bring problems to their attention. This may involve liaison associated with formal documents such as requests for proposals (RFQ) or contracts (K). More informal exchanges may arise from field reports, discussion of needs, etc.
- L2: In the "Generation of Ideas" process, the liaison function likely occurs primarily in informal discussions involving the R&D group and the ultimate or intermediate users.

Briefly:

- L3: A transition interface - liaison affecting the selection of ideas to be worked on. Typically customer-contractor; marketing-R&D.
- L4: A coordination interface liaison between parallel groups in work flow.
- L5: A transition interface bringing attention to work done outside of the normal organizational channels.
- L6: A transition interface same as L3.
- L7: A coordination interface same as L4 except now usually at advanced development or engineering stages.
- L8: A transition interface bridging to production; selection of actual items to go into the end product.

### 2.3.3 - Interface Communications

The General Interface Model, Figure 2.3-3, provides a perspective on some of the processes that may occur when communication between organization units takes place. Consider a communication from Organization "A" to "B." When the message is received, the significance of its content and action implications are perceived. The message may then be passed on through the internal communication processes to the individuals who must take certain actions to carry out the import or implications of the message. Depending upon the nature of the



\* RFQ = Request for Quotation  
K = Contract Award

Fig. -2.3-2 - Liaison Function Entry Points

**Source:** Douds and Rubenstein (1966)

message, this may lead to decisions or new problems that are communicated back to the originating organization.

In any case, there must be a decision to communicate a transmission, and a receiving process. The forms of communication are varied--written, graphic, and verbal. The forms of communication undoubtedly have an effect upon the interface, but not in any easily determined manner.

The General Interface Model applies to either transition or coordinative interfaces and distinguishes the transmission process from the receiving process. However, as presented here, it applies most directly to the non-face-to-face, non-immediate-interaction forms of interface communication. It does not obviously suggest the structure of the interaction processes taking place when the communications occur in a face-to-face situation or a telephone conversation. But whatever comes out of these interactive situations must get to the points in the organization where it can affect the flow of work. This involves the internal communications and internal activities of one or both organizations as indicated in the model.

At some point, the internal activities of Organization B result in an R and D event stage-transition if that organization is downstream in the flow of work. If both organizations are involved in the flow of work so that the interface is a coordinative one, then outputs are required from both groups to effect a stage-transition.

The function of "liaison agent" appears quite often in organizations. Burns (1961) has explicitly examined this function in connection with the R and D process, notably in the transition stages of carrying a product or process from research to development to production. His presentation would seem to indicate that the introduction of liaison agents can create as many problems as it cures. But certainly there are also successful cases of information exchange. The form of the liaison function at organizational interfaces can vary. The function may be handled as an additional role assumed by one or several persons performing another function.

Consider two small groups physically adjacent to each other, to the extent that their normal locations of work--desks, benches--are intermingled. They are working on different aspects of the same project. In the normal course of





events, the members of each group will communicate with the members of the other group about a wide range of topics--weather, ball scores, the latest rumors, or work problems and successes. If we then place the groups in adjoining rooms, there will be a noticeable drop in the frequency of communication. Place them at opposite ends of a 100-foot hall and a very decided drop in communication can be expected. Some of the members will speak to each other only rarely, but others will maintain fairly frequent contact. The total frequency of communication acts will probably be lower and the variety of subject matter/contact will be expected to change to a higher ratio of project to non-project matter. Move the groups into separate buildings, across town, into different towns, etc., and the frequency and ratio will be expected to change further.

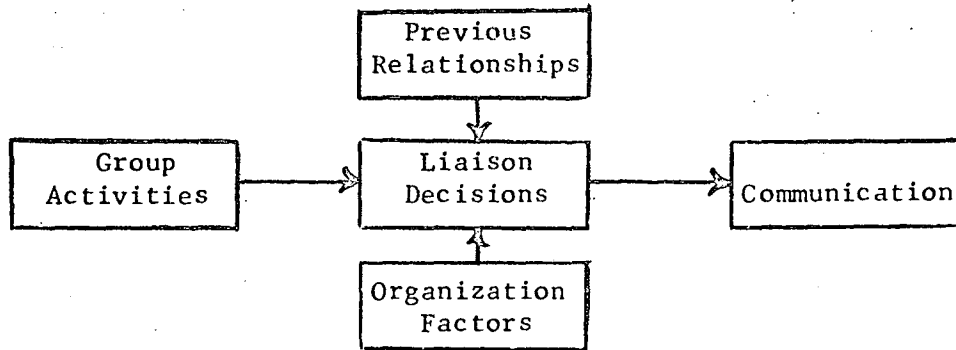
As this picture develops, we can easily visualize the communication becoming more and more concentrated in a limited number of individuals--most likely one or two--in each group. It is also possible that one (or a few) individuals in one group would communicate with a number of members of the other group. Another possibility is that a third party would enter the scene, acting as an intermediary in carrying communications between the groups.

Each of the individuals described is acting in the role of a liaison agent, with all or part of the communication between the groups funneled through him. The function of the liaison agent is to facilitate communication between the organizations or organizational units involved in an interface situation.

#### 2.3.4 - Interface Transmission Process

This discussion focusses upon the liaison agent and his transmission of information out of his organization or group (unit). Three aspects are involved: the individual, the group or project, and the organization.

In gross terms the Interface Transmission Process model, Figure 2.3-4, may be reduced to the following:

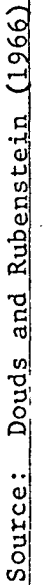


The communications crossing the interface originate from the decisions of individuals to communicate some particular content at various times and in various manners. These decisions and the content of the communication--which may also be decisions--arise from group activities in the flow of work (or, in some cases, the activities performed at an earlier time); factors involving the manner in which the organization operates; and the previous relationships of the individual, and his activities in the group in the liaison situation.

The interface communications originated are determined by content, frequency of communication, and the number of interface communication channels. The latter two determine the total quantity of interface communication events. The number of channels is determined by the explicit form of the organization structure and the (implicit) organizational controls and (explicit) procedures as they affect the individual's perceived freedom to communicate.

The decision of an individual to initiate an actual communication is determined by his perceived freedom, his feelings and knowledge of the intended recipient, and the perceived urgency of the matter if it exceeds his motivation threshold. The decision to communicate includes selection of the mode of communication--phone, writing, visiting, etc. Both this and the threshold are affected by the physical barriers--distance, configuration of buildings, etc. The occurrence of decisions over time determines the frequency of communication, of course.

The content of the communication is influenced by the mode, the perceived urgency, the technical competence of the liaison agent, his feelings toward and knowledge of the recipient and his project or organization goal orientation. His goal orientation is a filtering process that determines his "slant" on what



he will say and what he hopes to get out of the communication. It filters the actual subject matter--be it technical, managerial or administrative--coming from the group's problems or activities in determining the content of the communication.

This goal orientation is influenced by a variety of factors. In part, it is influenced by his knowledge and perceptions of the organization's objectives and the customer's project objectives. In part, it is influenced by his own personal aspirations, his career, etc. These and related factors are, in turn, affected by the way he has evaluated the information he has received about what is going on, the people he is working with, what is to be done, etc. Underlying these perceptions and evaluations are his work-related values.

In the next chapter several propositions are developed focussing on work-related values as the independent variable. They are related to the coupling of the activities across the interface between pairs of groups in terms of the level of communication problems perceived to exist between the groups.

## Chapter 3

### THEORETICAL CONSIDERATION OF COUPLING, COMMUNICATION, AND VALUES

#### 3.1 - OVERVIEW

The previous chapter has provided an overview of the R&D process and an examination of the coupling process. The topic of this research is not concerned with the whole of the coupling phenomena in R&D. The variable we seek to understand more fully concerns the information exchange process between R&D working groups. In this chapter some of the theory pertaining to various factors involved in the process is examined and a set of propositions is developed.

The following section considers coupling as involving the communication and utilization of information. This study deals primarily with the effectiveness of communication as it is perceived by the participants in the process. This is done in terms of a variable measuring perceived communication problems. However, the necessity for communication between groups is affected by the task structure of the work they are engaged in. Section 3.3 considers "task interdependence." Four dimensions indicating the nature of the relationship between groups are developed. Section 3.4 explores some of the prior literature concerning values and their effects in the organization. The propositions used to design the field study are developed in the remaining sections. Section 3.5 considers the effects of similarity or dissimilarity of values on perceived communication problems, and also the effects of within group homogeneity of values. These lead to some implications for people performing coupling roles (considered in section 3.6) which also make clear that the effects of perception upon values must be considered. Propositions relating to the effects of value perception are developed in section 3.7. The propositions are summarized in section 3.8, and groups as a unit of analysis are discussed in the last section.

### 3.2 - ASPECTS OF COUPLING

Coordination of the work of various organizational units--divisions, departments, sections, groups, and individuals--is a basic task in the management of all organizations. In R&D, the term "coupling" has come to be applied to the process of linking the work outputs of one R&D component to another. Sometimes the term is applied to links established across stages of the process, as indicated, for instance in the title of a symposium on the topic: "Coupling Research and Production" (Martin and Willens, 1967), or it may be applied to the linkages that are established among the groups involved in carrying out a project.

For managers the coupling problem is two-fold. One aspect is to insure that there is a continuing flow of timely information with appropriate content moving between related groups. The other aspect of the problem is to insure that the information is utilized appropriately in the work of one or both groups.

"Coupling" refers to the process of information transfer among groups and the utilization made of that information. This process is structured, in part, by the way tasks are assigned to groups, the types of decisions they make in carrying out these tasks, the flow of work, and the resultant manner in which the groups become interdependent upon one another for information and decisions.

The decisions and actions of managers external to the working groups can very directly affect the process. They can choose which groups will receive what assignments, who will comprise what groups, establish rules about who can talk to whom, establish new information services, and so on. The process may also be modified by actions taken within the groups--their response to special requests, informally or formally designating one member as a liaison agent with other groups, etc.

Various types of relationships will be established with other groups. Some groups may initiate work for others and monitor or control its progress. Others may be dependent upon receiving work from another in order to be able to do their work. Some may provide advice developed from their work on other tasks not related to the project another group is working on. These are various aspects of the nature of the task interdependence of one group upon another in the process of coupling their activities.

### 3.2.1 - Coupling and Communication

Communication is a central phenomena of the coupling process. Indeed, it is centrally involved in all aspects of organization behavior and human behavior in general. Perhaps then it is not surprising that so pervasive a concept evades singular definition. For instance, Schramm provides the following:

Communication comes from the Latin communis, common. When we communicate we are trying to establish a "commonness" with someone. That is, we are trying to share information, an idea, or an attitude . . . The essence of communication is getting the receiver and the sender "tuned" together for a particular message. (1954, p. 3)

Cherry, in an excellent survey of the field, offers the following in an appendix of brief definitions and explications:

COMMUNICATION. Broadly: The establishment of a social unit from individuals, by the use of language or signs. The sharing of common sets of rules, for various goal-seeking activities. (There are many shades of opinion.)  
(1966, p. 305)

Schramm is addressing himself to mass communication and Cherry to a survey of knowledge about human communication in general. Newman (1960) provides an extensive sampling of such definitions and points out the problems in defining the term and observes that a lack of a definition is not as serious as it might seem to some. No definition of itself will change the nature of the phenomena, and like extreme operationalism in definition, might only inhibit growth in understanding. This may be part of the reason that in the literature few reports of studies include a definition of communication--one has to look to the operations that were performed to determine the implicit operational definition.

Guetzkow, in his survey of communication studies regarding organizations, notes two aspects for attention, "communications as message flows and communication as message contents," (1965, p. 534). When the frequency of contact or direction of initiation, for example, are taken as the variables of interest, the focus is on flows. Studies related to message contents appear to more often specify variables in terms of the effects of the contents upon the individual in terms such as satisfaction with communication, acceptance, or sharing. Representative examples of these variables are given in the Profile of Organization



Characteristics questionnaire developed by the Institute for Social Research (Likert, 1967, pp. 201-202).

In R&D, teams are created to engage in a problem identifying, problem solving process. Uncertainties abound. There is a great deal of information within and without the organization that can be potentially used effectively. Because many groups are involved at various stages, much information must be exchanged among the groups and individuals.

(T)he effective solution of research problems by groups or teams organizationally designed for that purpose is highly dependent upon the availability and utilization of channels of interpersonal communication for the transfer of information. Despite the intellectual resources of the group members and the facilities available to them, group problem solution may be highly ineffective without adequate flow of information to and between group members.

(Rubenstein, 1953)

This refers to communication both within and among R&D groups. Coupling, as the term is currently used, refers to communication between groups. Coupling may be defined as the process of information transfer among groups and the utilization made of that information. It involves the network within the organization through which messages flow, the character of the messages, and their effects on the problem-solving, decision-making process that the researchers and designers engage in.

This latter aspect is of particular importance. "The critical question is whether the purposes of the sender and the receiver will be fulfilled by the transfer of information between them," (Rubenstein, 1957). Not only must the sender be able to send the message and the receiver get it, (the channel problem), and the receiver be able to comprehend it (the semantic problem), he must also take it into account in his subsequent actions (the pragmatic problem). The communication must be effective. By effective communication, Rubenstein means more than merely: "Did the message get to the right place at the right time?" or, "Did the recipient understand the message?" He defines effective communication as meaning: "1) that the objectives of the sender, with respect to particular messages, will have a high probability of being fulfilled; and, 2) that the uncertainty of fulfillment is due to factors other than the communication process itself."

Such a definition clearly indicates the central focus on the purposive nature of communication in organizations--communication intended to provide or obtain information to be used in the decisions made by managers, engineers, or secretaries.

The messages may serve any of a wide variety of purposes, such as starting work on a task, requesting needed information, reporting on progress, and so on. In R&D, with its emphasis on developing new knowledge and its application, there is particular concern with the communication of new ideas by their originators and how research and development personnel search for technical information in solving their research or design problems.\*

### 3.2.2 - Communication Measures

As indicated in Chapter 2, we view information flows and workflows as intimately related, if not identical, in R&D. A basic input to the R&D process is information. The output often takes the form of "hardware," but hardware is important only insofar as it provides substance for activity and information flow content. The transformations that take place in the information flow result in a reduction of uncertainty. Indeed, information can be defined in terms of uncertainty (Shannon and Weaver, 1949, p. 116). But we must be careful to distinguish levels at which we consider communication and information. Weaver notes three levels (p. 96):

- A. How accurately can the symbols of communication be transmitted?  
(The technical problem.)
- B. How precisely do the transmitted symbols convey the desired meaning? (The semantic problem.)
- C. How effectively does the received meaning affect conduct in the desired way? (The effectiveness problem.)

In organizational communications of the type being discussed here, we are not concerned with the "technical problem" as defined by A. We seek a measure of communication or information exchange as it relates to the accomplishments of

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\* These have been the topic of two on-going projects in the Program of Research on the Management of Research and Development: the Idea Flow project (cf., Baker, 1965; Utterbach, 1965; Pound, 1966; Baker, Siegman and Rubenstein, 1967; Maher, 1970), and the Information-Seeking Behavior project (cf., Werner, 1967; Moor, 1969; Thompson, 1969; Werner, 1969).

the work objectives of a group. We are primarily interested in the "effectiveness problem," C, with perhaps some aspects of the "semantic problem," B, included. (Weaver notes that the levels overlap.) "Even questions of syntax or semantics have their pragmatic aspects," (Rubenstein and Haberstroh, 1966).

The development of information theory engendered by the appearance of Shannon and Weaver's book stimulated a great deal of interest among behavioral scientists. It has found useful applications in some behavioral fields, such as certain studies of perception (cf. Gibson, 1970). But the problems of developing measures of information exchange at the so-called pragmatic (effectiveness) level are formidable. Such measures would be of direct use in the study of the coupling between technical groups in R&D. Efforts have been made to develop such measures but there are not any available as yet that are feasible to use in studies of formal organizations.\*

Many approaches have been taken to measuring communication in organizations. This variety arises for several reasons. One is that there are several areas of investigation. Thayer (1968) distinguishes four: intra-personal, inter-personal, organizational, and technological. There are no "standard" conceptual or operational definitions. The only well-accepted unit of measurement for information is the "bit" which is applicable only at the syntactic level and primarily used with utility only in technological applications (e.g., in telephone, television, and radar systems). In addition to the levels of information-- syntactic, semantic, and pragmatic-- and the various areas of investigation within the organization, there are also various characteristics of the process subject to study, such as message comprehensibility, validity, and utility, communication effectiveness, communication efficiency, and communication system efficacy (Thayer, 1968).

With a concept of such broad scope, it is not surprising that many techniques have arisen to measure communication in organizations. The techniques used include unobtrusive measures, item-tracking, activity sampling, self-reporting, observation, group dynamics measures, participant observation, content analysis,

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\* A brief overview of measures of communication is given in Appendix 3. It makes clear that there is no present measure of information, comparable to the measure provided by Shannon for information at the syntactic level, adequate to provide a measure of information of the pragmatic level. This discussion also indicates some of the relations between values and information exchange.

content and attitude questionnaires, critical incident, error-choice, sociometric and interview techniques. Some of the purposes to which these techniques are put, and their advantages and limitations are discussed in Douds (1966). With suitable design, comparable measures can be obtained from several of the techniques to provide cross-validation for the variables of interest. However, there are large differences in the feasibility of using the techniques in any given situation as determined by the purposes of the research, the resources available to the researcher, and the limitations imposed by the organizations he studies.

Guetzkow (1965) discusses communication networks in organizations, but along with March and Simon (1958), Leavitt and Bass (1964), and Katz and Kahn (1966), he finds little field data on which theory about this basic element of organizational activity can be built. As of 1969 there appeared to be but one study, Weiss (1956), in the behavioral science literature which determined the communication network of an organization component of any size (and it is not referenced by these writers). It is limited to undifferentiated communication activity, not distinguishing among communications for various purposes.

Most authors concerned with organization theory and small group dynamics provide hypotheses and partial theories concerned with communication and its effects upon behavior. But with the abundance and richness of theoretically proposed variables and relationships, there is also an attendant lack of field study to confirm or disconfirm the hypotheses. Having referred to two summaries concerned with individuals and small groups, Guetzkow (1965, p. 535) states:

Thus it is possible to make easy reference to the underlying researchers covered in the summaries, as we proceed toward our goal of understanding more adequately the ways in which communication systems operate in organizations. The richness of materials at the individual and group (small group laboratory) levels has induced extrapolation of findings perhaps inappropriate for rigorous analysis of communications in organizations. Yet with the dearth of studies about organizations, either from the field or laboratory, one can but join with others in speculation.

Katz and Kahn (1966, p. 247) note: "There are no studies of the distinctive types of communication which characteristically flow horizontally, upward, or downward in organizations, although such research is much needed." It is also to be noted that although they utilize the orientation of "open systems theory," they maintain the distinction of vertical versus horizontal communication.

While we are nominally concerned with "horizontal" communications in this study, our focus is on task-related problem-solving communication between group pairs. The groups may be located anywhere in the R&D organization, as long as they are working on task problems. The nature of the relationship may be described in terms of their perceptions of the level of the relationship using the "task interdependence dimensions" developed in a later section.

### 3.2.3 - Aspects of Communication "Effectiveness:" Communication Problems

The dependent variable of this study is, in a sense, communication "effectiveness" as perceived by the participants in the communication process. There is no completely satisfactory definition of communication effectiveness and we shall not attempt one. Rather, we shall focus on some of the problems that can occur in the communication process among individuals. These are fairly readily recognized and are readily converted into operational indicators (which will be found in Chapter 4).

This approach takes into account the potential disparity between the information needs of the receiver and what he obtains when. The focus is on task-related, problem-stating, problem-solving information. It should be noted that it does not fully take into account the information utilization aspect of the coupling process. The material developed here is a necessary first step in the development of a full measure for coupling effectiveness.

The items for the variable, Perceived Communication Problems (PCP), were derived from the material following in such a manner as to allow for the realities of the communication process at various levels of interdependence between the groups. For instance, it is not always necessary that information requests be fulfilled immediately. Time delays are a normal part of the process. It is only when information is received later than needed, or when a change is made by one group that affects another group but they are not told about it, etc., that problems develop.

Miller (1960) has classified the responses to information input overload into seven categories: (1) omission, failing to process some of the information; (2) error, processing information incorrectly; (3) queuing, delaying during periods of peak load in the hope of catching up during lulls; (4) filtering, neglecting to process certain types of information, according to some scheme

of priorities; (5) approximation, or cutting categories of discrimination; (6) employing multiple channels or using parallel channels; and (7) escape, not performing the task.

Miller treats these seven types of responses as mechanisms of adjustment, (but as Katz and Kahn (1966) note, at the organizational level they may be adaptive or maladaptive mechanisms for the functioning of the system). These responses, that may be observed at the output of an organizational unit, whether the unit be a department, a group, or an individual, may arise in a variety of ways other than just from input overload. Queuing and escape lead to time delays in another unit receiving information relevant to them.

Pfifner (1960, p. 129) notes that, "The effectiveness of communication as related to decision-making is dependent not only on the fullness and accuracy of information but also on the interaction processes in the organization--who gets what information when." (Underscore added.)

Error leads directly to inaccuracy or distortion in the information content, to which omission, filtering, and approximation may also contribute. Restriction of content or topics communicated--what is communicated may be accurate but not the whole story--is the direct result of filtering and contributed to by approximation. Over time, continual restriction of the content communicated on any occasion will lead to reduction in the total quantity of relevant information communicated from one group to another.

The utilization of communication channels, or the lack thereof, is reflected in communication difficulties. These can take the form of:

- Delay: from request or initiation of action to response.
- Distortion: in substantive content (inaccuracy).
- Restriction: of content or topics communicated. (What is communicated may be accurate but it may not be "the whole story.")
- Reduction: with respect to quantity. (Frequency may be the same and topics covered may be the same but less is said.)

In addition to the above measures of the communication process, the actual information exchange properties of the process can be examined. The following indicate the quality of information exchange:

- Extent of "other" keeping/not keeping respondent informed on status of

activities, projected outcome status, or objectives, that are of significance to respondent.

- Extent of changes or requests for information that come unexpectedly requiring substantial effort.
- Extent of changes that the respondent sees as unwarranted, unnecessary, etc.
- Respondent's certainty with respect to knowledge provided by other as to what is needed, what to do, how to do it, etc.

Closely related to the information exchange process is the decision making process involving the group pair and the level of conflict-cooperation involved in their joint activities. Measures providing or reflecting indications of the decision making process are:

- Difficulty or effort required to make joint decisions or decide on respective courses of action. (The level of difficulty of technical problems involved would also have to be taken into account.)
- Extent of conflict/cooperation in joint decision behavior; also operationalized as:
- Extent of utilization of ideas, information, etc., provided to other group (unitary decision behavior of other).
- Relevance and utilization of ideas, information, etc., received from other group (unitary decision behavior of respondent).

The availability of channels can be determined in terms of limitations in the potential linkages. The types are (Rubenstein, 1954):

- Channel limitation: restriction in number of people communicating.
- Frequency limitation: restriction in number of occasions.
- Form limitation: restriction/requirements in written or verbal forms.

These are various aspects and indications of the effectiveness of the information exchange aspect of the coupling process as they relate to the perceived communication problems. More objective measures could also be built upon the same items to determine the relationship between the perceived and the "actual" communication problems. In one sense, such work could be considered as "validation" of a measure for a communication effectiveness variable. Undoubtedly, there would be discrepancies between the two. But such discrepancies would be a suitable topic for investigation of themselves. The factors that contribute to them could turn out to be significant in determining coupling effectiveness, and

might provide important clues to methods for increasing coupling effectiveness. It will be argued later that the measurement of perceived communication problems is the appropriate measure for the propositions of this study.

#### 3.2.4 - Coupling as a Workflow Process

The coupling of groups, departments, or organizations is a complex phenomenon. In the following sections we shall consider some aspects of the relations between working groups in R&D organizations primarily in terms of the interdependence created between groups by their place in the work flow and the information they possess, receive, generate, and transmit.

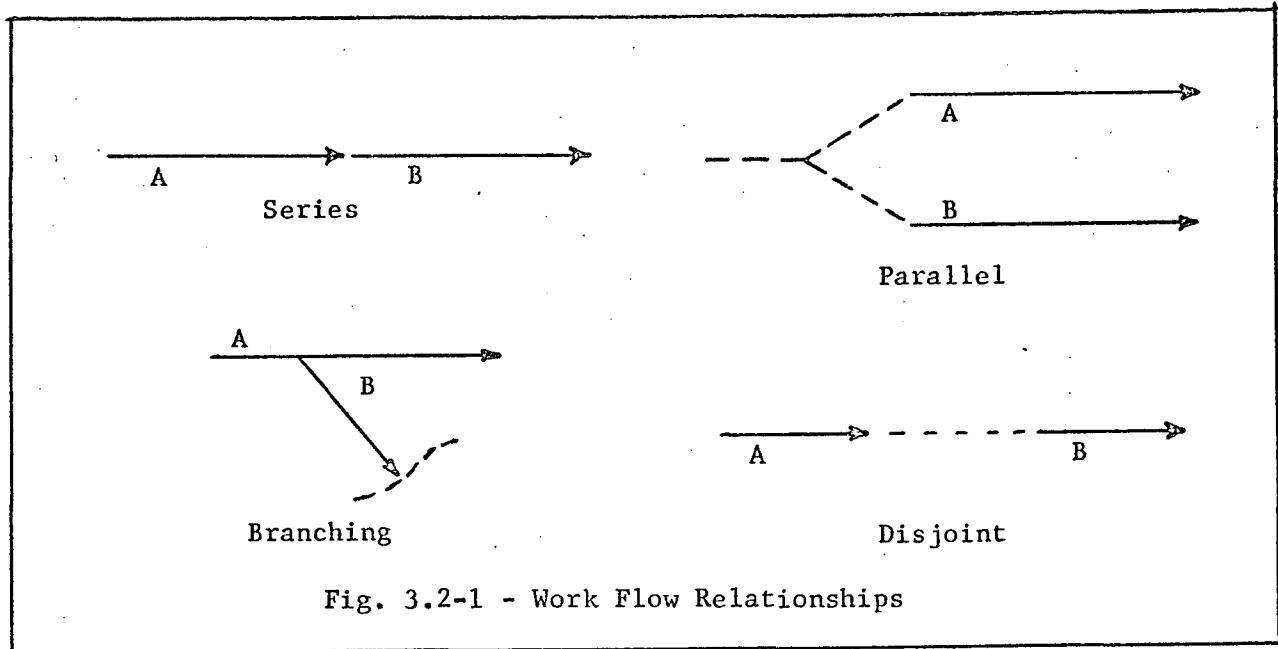
At one point in time a project is an idea held by one or a few people. At some later point in time, assuming that a number of appropriate decisions have been made, the project is completed with the production of a report, drawing, demonstration, etc., or merely the cessation of activity which nevertheless leaves its imprint upon those who engaged in it. Between this beginning point and end point there has been a flow of work on the project. Perhaps it has been a continuous one; or perhaps it has been interrupted from time to time. The work flow consists of recurring inputs of information, transformations of it, and outputs of information through time. These processes are characterized by inter-related events and activities whose complexity is sometimes graphically displayed on PERT charts.\* When more than one group is involved--the situation we are concerned with--there is a workflow among the groups carrying out these activities.

The sequential relationship between any two groups may be serial, parallel, branching, or disjoint as sketched in Figure 3.2-1. In a series relationship the output of one group becomes the input of the second. In a parallel relationship the activities of the two groups proceed concurrently. A disjoint relationship refers to the situation where the activity of one group on a project task is completed some time before a second group begins activities making use of that output. The branching relationship is a special case of the series relationship introduced to describe the situation where inputs are received from the organizational boundary or output toward the boundary while "main-

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\* PERT (Program Evaluation Review Technique) is an analytical tool used in project management for evaluating planned schedules and the impact of schedule changes. It involves, among other things, estimating the time duration of the activities in a project and the inter-relationship of the activities. This provides a network of activities and relationships which can be graphically displayed. The first application of PERT is described in Malcolm, et al (1959), and a later application in Sadow (1964).



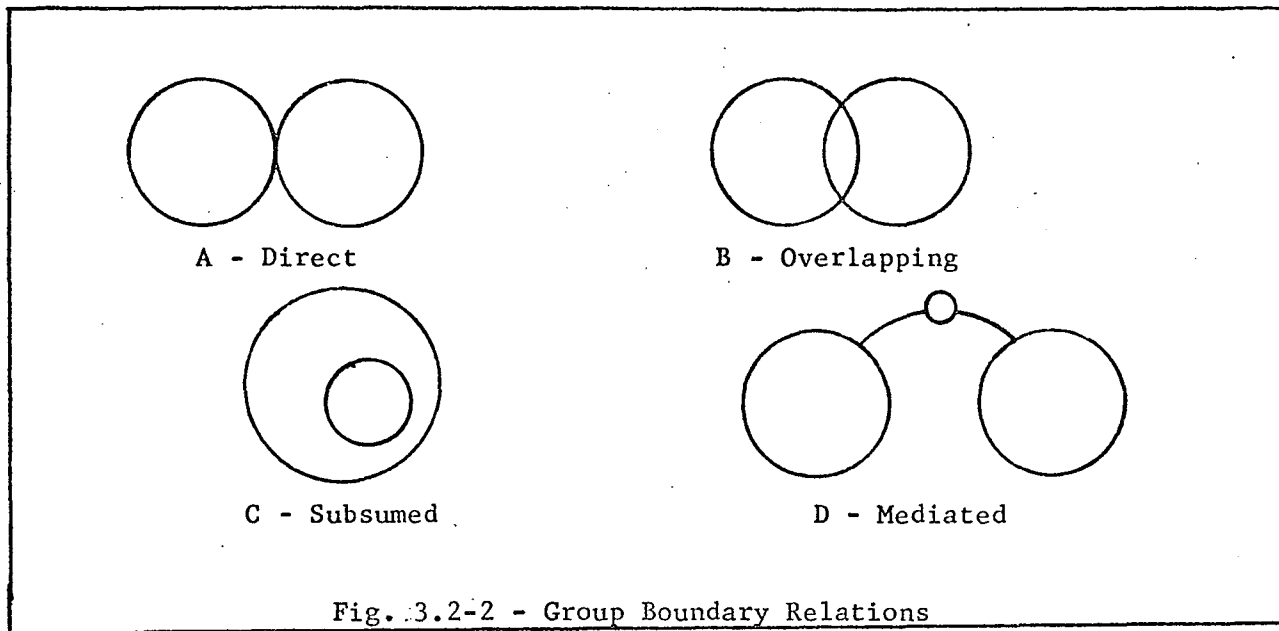


stream" activity proceeds. Personnel, receiving-inspection, and purchasing units would typically have such relationships with development groups.

The workflow determines the basic input-output structure of information flows leading to the completion of a project.

### 3.2.5 - Group Boundary Relations

Two groups in the same or different flows of work may be related to each other in one of four ways as indicated in Figure 3.2-2. In A there is a direct coupling of the groups. Information going from one group to the other crosses two boundaries. In B the groups overlap--one or more persons working in one group also work in the second group. Information going from one group to the other still passes two group boundaries to the extent that the boundary can be defined. In C one group is wholly subsumed in the second group. Information passing between the groups crosses only one boundary. In strictly social situations, such a group is called a clique; in organizations it may be appropriate to call it a clique or a cabal (Burns, 1955). On an organization chart it might be a section within a department. "Group" is a relative term depending upon the purposes of the researcher or organizational designer. In a study of organizational structures a department might be considered a "group" and a



section in the department a subsumed group of type C. The smallest formally recognized unit may be the basic work unit of an organization. However, situations of a distinct "work group" wholly subsumed within another "work group" do occur.\*

In D there is no direct interaction between the groups; the information flow between them is mediated by some other person or group. Information must cross at least four boundaries. At this point we specify no further characteristics other than that there is an interaction between the groups and that the information is not transmitted directly from one group to the second. Since all groups in an organization may be linked in this manner, it is appropriate to ask if this represents an "interface" situation. If adequate activity performance by

\*In a prior study, the author interviewed a manager in a company performing classified work. His group was composed of a number of people who worked in one room and several others who worked in a locked vault contained within the larger room. Both sets knew each other well and socialized freely at lunch hours. At one time the group in the vault encountered a problem they could not solve in a practical manner. To the manager's embarrassment, his customer in Washington acted as "liaison agent" between the groups in solving the problem by suggesting that they try a device developed by the group in the outer room several years before.

one group, or inputs of information from it, are required for the second group to be able to adequately perform their activities, it is an interface where the information or work flows are mediated by a third party.

### 3.3 - TASK INTERDEPENDENCE

#### 3.3.1 - General Characteristics

A basic characteristic of modern formal organizations is the division of labor allowing for task specialization. This results in most groups or individuals, whether or not they are aware of it, being dependent upon many other groups to a greater or lesser extent in order for them to perform their work satisfactorily.

Thompson (1967) distinguishes three forms of internal interdependence in formal organizations: pooled, sequential, and reciprocal.

To assume that an organization is composed of interdependent parts is not necessarily to say that each part is dependent on, and supports, every other part in any direct way. The Tuscaloosa branch of an organization may not interact at all with the Oshkosh branch, and neither may have contact with the Kokomo branch. Yet they may be interdependent in the sense that unless each performs adequately, the total organization is jeopardized; failure of any one can threaten the whole and thus the other parts. (p. 59)

This form of interdependence is called pooled interdependence. There is no common work flow linking the parts. In an industrial organization or a comparable unit of a government (e.g., the Department of Defense), the relationship of R&D to many of the other components of the organization may be of this form. Within an R&D organization, especially if a "coupling problem" exists, the relationship between research and development could be one of pooled interdependence.

When the work output of one unit becomes the input to another unit, the interdependence has taken a serial form. Thompson refers to this as sequential interdependence, and notes that it is not symmetrical (p. 54). Here two units so related are in the same work flow.

A third form of interdependence Thompson calls reciprocal, in the situation where the outputs of each become inputs for the other. "... the distinguishing aspect is the reciprocity of the interdependence, with each unit posing contingency for the other " (p. 55).

In the order introduced, the three types of interdependence are increasingly difficult to coordinate because they contain increasing degrees of contingency. With pooled interdependence, action in each position can proceed without regard to action in other positions so long as the overall organization remains viable. With sequential interdependence, however, each position in the set must be readjusted if any one of them acts improperly or fails to meet expectations. There is always an element of potential contingency with sequential interdependence. With reciprocal interdependence, contingency is not merely potential, for the actions of each position in the set must be adjusted to the actions of one or more others in the set. (p. 55)

Thompson uses "contingencies" to refer to decisions on the part of one unit that directly affect, or are shared with, another unit. Each group in an organization is normally directly dependent upon several other groups. Some may make decisions affecting them and provide them with needed information. To others they may provide information, decisions, and their work output. There will also be groups or individuals--frequently managers--that evaluate their output and direct their activities. Groups "downstream" in the main line of work flow are dependent upon groups "upstream" from them to provide the inputs for their activities in a very direct manner. But similarly, the upstream group, in order to adequately perform its work, may be dependent upon the downstream group to the extent that the downstream group has to carry through on the work it initiated and to feed back information to them for future corrective action and for their own learning to take place.

Walton and Dutton (1969) develop a general model of interunit relations to explain the antecedents and consequences of "frictional" conflict (Pondy, 1969) in organizations. Mutual task dependence is stated as being "the key variable in the relevance of the interunit conflict model in general and the impact of the postulated conflict antecedents in particular." It is defined as "the extent to which two units depend upon each other for assistance, information, compliance, or other coordinative acts in the performance of their respective tasks." Mutual task dependence can provide an incentive for collaboration but it also can provide the source for conflict and bargaining behavior in regard to interdepartmental issues (Dutton and Walton, 1966).

Dependence of one group on another may arise externally to the group because of the nature of the information requirements of project tasks they are working on or the way the work and the organization has been structured. The dependence

may also arise internally to the group; for instance, from the way they structure their own work and schedule it, or from the extent to which they seek information about how their past products have performed.

In R&D, the complex physical interrelationships, governed by laws of nature, create interdependencies among groups working on various aspects of a problem, particularly in the design stages. These relationships may play a part in determining the work flow structure and will affect the content of the interface relationships. The effects of some of these technologically based dependencies were observed by Eyring (1966). For instance, in one case an antenna design group relaxed its design goals when it learned that the receiver group on the project had raised its design goals and seemed likely to be able to meet them. In another instance on the same project, a mechanical group began the development of a more powerful (and more expensive) motor drive before there was any official change in the specifications, anticipating from what it learned from another group that they would not be able to meet their design goals.

The level of task dependence of one group on another will not necessarily be the same for both groups. For instance, in the case of two serially linked groups, the downstream group may only be able to do its work satisfactorily if the upstream group provides timely and adequate information and work output to them; but the upstream group may not be nearly so dependent upon outputs of the downstream group for it to do its work adequately.

Kahn, et al, in their study of individual role stress define "functional dependence" in this manner: "To the extent that the organizational division of labor creates pairs of positions for which adequate activity performance of one position is requisite to the adequate activity performance of the second, these positions may be said to be functionally interdependent," (1964, p. 168). This was operationalized by presenting one person with a list of the major activities performed by another and asking him to respond to the question, "From the standpoint of how it affects your own job, how much does it concern you that this gets done properly? The functional dependence of (person A) on (person B) was determined by the percentage of the latter's activities which ... concerned him at least 'somewhat'" from a four-point scale of: very much, somewhat, not so much, not at all (p. 168). They also note that this "interdependence" is not necessarily symmetrical, as was just indicated.

Walton and Dutton (1969) propose that task-related asymmetries in dependence and various dimensions of organizational status, namely direction of initiation of action, prestige, power, and knowledge, produce conflicts, based on findings in studies by Dalton (1959), Strauss (1962), Seiler (1963), Lawrence and Lorsch (1967a), Landsberger (1961), and Zald (1962). They propose that asymmetrical interdependence leads to conflict. One of the symptoms of conflict is problems in communication and the rationing (restriction) of information exchanged between groups. But as noted above, the normal flow of work involves serial relationships between some groups in the work flow and thereby a sequential dependence, in Thompson's terms, with one group normally initiating work for another. Walton and Dutton do not consider the effects of the work flow and the form of the dependence. From the sources they utilize (Dalton, 1959; Strauss, 1962) it appears that they are primarily considering branching work flows and high levels of asymmetry.

Where the work of one group affects the work of another group there is some level of task dependence between them. How adequately one group does its work will affect the work of others in the same or related work flows. For instance, design changes are frequently made in development work. When such changes are made by one group, another group may also have to make important changes in what it is doing, while others may be little affected. The former case would imply that a high level of task dependence of one group on the other probably exists; the latter, a low level of dependence.

Task dependence defined in terms of "adequate activity performance" relates to the various tasks that comprise the work being done by a group. In R&D, these tasks lead to specific events such as an experiment, a proposal, a completed design, or a prototype model. In some cases, the criteria as to whether or not the event was successful--and the work leading to it thereby at least adequate--are reasonably clear. The data needed was obtained from the experiment, the proposal was accepted, etc. More often, the criteria are less clear. Eyring (1966) found that several task leaders on one project defined their work in terms of technical "problems." Their work was adequate when they were solving these problems by meeting their technical specifications. Time, manpower, and cost objectives were also involved for these individuals, but not as strongly as for the higher managers.

Failures, perturbations, or changes in the work done by one group can affect simply the time and effort required by another group to adequately perform its activities. They can also affect the quality of what is produced. In R&D projects, the effects can readily be extensive when key technological trade-offs are involved. Failure to attain a particular technical goal by one group can sometimes be compensated for by exceeding another technical goal, but the state of the art (or the resources or time available) may not allow this, and thereby jeopardize an entire project.

Task interdependence is defined as the extent to which one task group depends upon another for information--including work inputs and outputs--decisions, and actions for them to be able to perform their own work. Interdependence may exist in terms of short term activities--work on task elements--or in terms of the end results of longer term activities such as major tasks or complete projects.

The higher the task interdependence of a pair of groups the more active the coupling process between the groups will have to be. But the necessary level will be affected by the technological characteristics of the task--both initially and as they change with time as work progresses-- and characteristics of the organization that affect the timing, sequence, and type of information inputs and decisions needed. The actual level of activity in the coupling process, in addition, will be affected by the characteristics of the groups, their members, and the units of which they are a part.

Depending upon the nature of the relationship between the groups, task interdependence may be symmetrical or asymmetrical. When the perceptions by one group of the nature of the relationship are not congruent with those of the other group, difficulties in the working relationship are likely to be encountered. As recorded above, this was noted by Dutton and Walton (1966) for mutual task dependence and treated theoretically by them when asymmetries in mutual dependence and various dimensions of organizational states exist (Walton and Dutton, 1969). In this paper mutual task dependence is called "a key variable." However, in their report of a field study based on the theory presented in 1969, they revise their view: "Dependence was treated as a separate factor in the earlier paper, whereas here it is included as one of several task conditions with frustration potential," (Walton, Dutton, and

Cafferty, 1970). The data indicates that their measure of mutual dependence does not have much explanatory power. One reason for this result, and their change of emphasis, may involve their instrumentation. A number of variables (at least 25, no explicit list is provided) are derived from an 80 item questionnaire. Another reason may be that mutual task dependence is a special case of task interdependence relations. Assymetry in task dependence relations between a pair of groups may be normal and expected. Rather than limiting consideration to mutual dependence, part of the explanation for conflict between two groups and attendant difficulties in communication, would appear to lie in the disparities between two groups in their perception of the nature of their dependency upon each other in the work flow as it is structured.

In the next section we shall consider several "dimensions" describing the nature of task interdependence between groups. Indicators for these are given in Chapter 4 and the indices for them are presented with their characteristics in Chapter 5.

### 3.3.2 - Nature of Task Relationships

The classic tradition of organization theory (e.g., Mooney and Reiley, 1939; Koontz and O'Donnell, 1955) expresses the relationship between organizational units primarily in terms of hierarchical authority, the assignment of responsibility, and the line/staff concept. These relationships are conceived of as the means through which the activities of planning, organizing, directing, controlling, staffing, evaluating, etc., are carried out. In the traditional theory these are viewed primarily as managerial activities, but activities of this type take place at all levels in the organization. Norden (1964) was able to solve a problem in his work on the development of a manpower prediction scheme for R&D projects by introducing the concept of work activity "purpose" into his prediction method. Draftsmen and machinists, for instance, spend time planning and organizing as well as "doing." These activities express various types of operations performed by organizational units--working groups or individuals, as well as managers. They are transformations made on information available to, or created by the unit. The information is used in the problem-solving, decision-making process that is defined by the responsibilities they have been assigned, accepted, or assumed. Traditional approaches give little consideration to the interaction of decisions made by various units and the information flows that support and affect these problem-solving processes.



The nature of the ~~complex~~ between groups in the work flow of R&D cannot be expressed adequately in these traditional terms of authority, assignment of responsibility, and line/staff structure. Line/staff concepts alone are not sufficient. Responsibility can define the nature of a groups' activities--the transformations it makes on information--as well as when and where it gets or provides its inputs and outputs. Traditionally, in discussing responsibility, the focus is on the activities, what the group does and how it does it, rather than on its relationships with other groups. "Responsibility" used in this way does not express the nature of the relationship with other groups.

"Authority" does involve the relations between one unit and another, but it is only one aspect of the relationship and subject to considerable problems, especially in R&D, arising from traditional viewpoints. The traditional notion of authority systems has been expanded by Scott, et al (1967), in terms of the process by which individuals' performance is evaluated. Their view allows for "lateral" as well as "vertical" authority relations, such as between quality control and production groups. In R&D, a field test group that evaluates products of development groups is in a similar role, but the question of "authority" in such situations is probably even more nebulous than the problem of "authority" between production and quality control.

The limitations of the authority concept are well illustrated in a study performed by Munsey (1966). He sought to find a way to describe the organizational processes and the relationships among the groups involved in checking out a rocket system for test firing. The concept of authority, Munsey knew from his prior personal experience in the activity, was essentially meaningless. With teams working together from several different commercial R&D firms, the Air Force, the Army, and the Navy, the usual sanctions of reward and punishment on either a short-term or long-term basis simply were not available. Nevertheless, the organizational system did work. It was possible to describe the activities of the groups and the structure of their relationships in terms of the sets of activities each performed and the nature of their interactions in terms of decisions, information inputs, outputs, and timing with respect to specific sets of activities. This was done as a modification of the "Linear Responsibility Charting" technique described in Karger and Murdick (1963). This

approach allows for "vertical," "lateral," "diagonal," etc., relationships without the necessity of specifying these directionalities; the focus is maintained on information flows, work processes, and decision points.\*

With respect to specific organizational design problems, the nature of the relationships of one group with others can be expressed through the technique just described. However, the form and level of the relation of one group with another can in general be expressed in terms of several dimensions of task interdependence.

Thompson (1967) distinguished three forms of interdependence among organizational units: pooled, sequential, and reciprocal. These are based on the dominant work flow among the units and the effects that the decisions of one unit have upon the other. Walton and Dutton (1969) define task dependence (mutual or asymmetrical) as "the extent to which two units depend upon each other for assistance, information, compliance, or other coordinative acts in the performance of their respective tasks." Kahn, et al (1964), studying individuals in organizations, define functional dependence as the extent to which "the adequate activity performance of one position is requisite to the adequate activity performance of the second." All of these definitions include the concept of effects upon activity performance, but the latter two do not include the nature of the work flow or form of the relationship.

The nature of the relationship between task groups can be expressed in terms of the level of task dependence of one group upon another measured on dimensions that express aspects of the work flow or information exchange and decisions involved. An organized system requires processes to provide internal control and regulation. In R&D, as work proceeds on a project, it is broken into successive task units, some of which must be completed before others are started, others of which can be worked on in parallel. There are a variety of ways this process may be structured by design or circumstance. A given group may have a greater or smaller role in initiating and influencing the work other groups perform. This may be because of their formally assigned role (in which case

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\* This same approach is described in Cleland and King (1968). However, the essential focus on information flows and decision points provided by Munsey is not fully retained by them.

"authority" may be involved), because of their position in the work flow, what they are working on, their specialized knowledge, etc. Thus one aspect of the nature of the relationship between groups is work initiation and influence. One would expect that a project manager's office would rate high on this dimension of task relationship.

In order to do its work, any group must receive information (or material) from other sources. Most of the time this will be the output of other groups or individuals. In many organizations this flow of information is highly routinized for much of the work most groups perform. In R&D, even at the lowest levels of the organization, this may be much more subject to change, depending upon the intrinsic technological requirements of the concept to be researched or developed, and the form of organization set up for the project. Each group is dependent upon other groups for information and decisions. Additionally, in order to successfully carry on their work, it may also be necessary for another group to make use of their output. Input/output dependence in the work flow is then another aspect of the relationship between task groups in the R&D process. If the same group that provides the input does not receive the output, then this is Thompson's "sequential" dependence.

When two groups are working in parallel where outputs of both become inputs for the other and there is a shared objective, then they have mutual dependence or "reciprocal" dependence in Thompson's terms. There is a concurrent input and output dependence of one upon the other. In R&D this frequently takes the form of trade-offs being possible in their task specifications. In such cases, the ability of one group to exceed its design goals may relax the requirements for the other--they no longer need to attain their design specifications. Or conversely, the inability of one to meet its specifications means that the other must exceed its requirements if the total system is to reach its over-all specifications. Each group needs information from the other during the course of their work that will enable them to adjust their design goals. In addition, many aspects of the design itself may have to be worked out mutually as work progresses. Planning decisions have to be made jointly and subsequent decisions made as the actual design and testing proceeds. This leads to the proposition, suggested by Thompson at the organizational level, that for a given pair of task groups, high mutual dependence will be accompanied by high input-output dependence.

The above three forms of relationship between task groups cover the situations where there may be a high or moderate level of interdependence between them. There is one additional type of relationship that, while it intrinsically implies a low level of dependence, is important to the coupling process and the potential transfer of new ideas or the creation of new applications. It arises strictly from information needs and resources, or skill limitations and abilities. Two groups may have no reason for dealing with each other arising from the structure of work and organization, but yet they may be coupled together from time to time to exchange ideas or seek solutions to specific problems. They may consult with each other to get advice based on one or the other's expertise.

A task relationship can be based on the giving and receiving of advice and consultation. This is a form of interdependence which by its very nature would tend to be associated with a low level of interdependence. If two groups are involved in a common project, they may, of course, provide advice to each other based on their prior experience on projects in which they were not associated-- but this would be applying past experience to a current problem in which they are dependent upon each other. They may also have other concurrent activities in which they are not related and obtain advice or consultation on those activities, so moderate or high levels of advisory and consultation dependence could also exist with moderate or high levels of other types of dependence.

The four "dimensions" of the level of task interdependence existing between a pair of groups describing the nature of the relationship that have been described here are:

- Work Initiation and Influence
- Input-Output Dependence
- Mutual Interdependence
- Advice and Consultation

### 3.4 - RELATIONSHIP OF VALUES TO ORGANIZATIONS

#### 3.4.1 - Values in the Social System

Organizations are social systems that consist of patterned behaviors on the part of many individuals and groups as they make decisions and communicate with each other. In the view of Katz and Kahn (1966), these social systems, as the patterned interdependent activities of people, are characterized by the sets of decisions and behaviors of the people ("roles") which differentiate one position from another, and they are characterized by a set of shared norms and values which serve to define limits on the permissible behaviors. Norms and values are used to refer to ". . . beliefs of an evaluative type which constitute a coherent interrelated syndrome. System norms make explicit the forms of behavior appropriate for members of the system. System values or ideology provide a more elaborate and generalized justification both for the appropriate behavior and for the activities and functions of the system " (pp. 51-52). They go on to point out that system norms and values are a group product and may not be necessarily identical with those the individuals hold privately. The system norms and values are a product of the entire group that comprises the organization, and there may be variations among the various subsystems that comprise the whole. Values are then one of the central factors in determining how an organization will behave, how its groups will behave, and how its members will behave.

Simon (1957) views organizations as functioning through a system of interrelated communication inputs to decisions. Values are central to the decision-making process. " . . . (E)very decision involves elements of two kinds, which (are) called 'factual' and 'value' elements respectively" (p.45). But the number of values, or decision premises (March and Simon, 1958), that can be incorporated into a decision are limited by the capabilities of man to examine all the consequences for their decisions, the knowledge available to them at the time of making the decision, etc., and the "non-rational" characteristics of man. "If an administrator, each time that he is faced with a decision, must perforce evaluate that decision in terms of the whole range of human values, rationality in administration is impossible. If he need consider the decision only in the light of limited organizational aims, his task is more nearly within the range of human powers" (Simon, 1957, p. 13). Simon also notes that:

It is a prevalent characteristic of human behavior that members of an organized group tend to identify with that group. In making decisions their organizational loyalty [or group loyalty] leads them to evaluate alternative courses of action in terms of the consequences of their action for the group. . . . Organizational loyalties lead also, however, to certain difficulties which should not be underestimated. The principal undesirable effect of identification is that it prevents the institutionalized individual from making correct decisions in cases where the restricted area of values with which he identifies himself must be weighed against other values outside the area.

(p. 12-13)

The cumulative impact of such learned organizational sub-unit values not only affects the decisions made, but also the information a person thinks he perceives through a process of "selective perception." Dearborn and Simon (1958) presented a case study to a group of executives from various functions in their firms during a training program and asked them to identify the most important problem in the case. They found that the sales executives mentioned sales problems significantly more often than did other executives, and that production executives examining the same material mentioned production problems significantly more often than others.

The centrality of values in organizational behavior is again indicated by Blau and Scott (1962):

The networks of social relations between individuals and groups, and the status structure defined by them, constitute the core of the social organization of a collectivity, but not the whole of it. The other main dimension of social organization is a system of shared beliefs and orientations, which serve as standards for human conduct. In the course of social interaction common notions arise as to how people should act and interact and what objectives are worthy of attainment. First, common values crystallize, values that govern the goals for which men strive--their ideals and their ideas of what is desirable. . . . Second, social norms develop--that is common expectations concerning how people ought to behave. . . .

(p. 4)

The constituent groups of the organization, like all groups, develop their own practices, values, norms, and social relations as their members live and work together.

(p. 6)

The study of the distinctive significance of group structure requires going beyond the human-relations approach to consider the networks of human relations and the common values which unite group members.

(p. 89)

The group climate or subculture is defined by the values and norms that prevail among the group members.

(p. 100)

In connection with this last statement, Blau goes on to discuss certain pro- or anticlient values that were held by the members of a social welfare agency he studied at length. He found that values affected the behavior of the professionals: "The combined effect of group and individual values on service orientation was considerable: 60 per cent of the proclient individuals in proclient groups were service oriented, in contrast to only 27 per cent of the anticlient individuals in anticlient groups." (p. 102)

The importance of communication and the flow of information is emphasized by Katz and Kahn (1966) who also relate it to values:

Communication is thus a social process of the broadest relevance in the functioning of any group, organization, or society. It is possible to subsume under it such forms of social interaction as the exertion of influence, cooperation, social contagion or imitation, and leadership. . . . The glorification of a full and free information flow is a healthy step forward in intraorganizational problems as well as in the relations of an organization to the larger social system. It is, however, a gross oversimplification. Communication may reveal problems as well as eliminate them. A conflict in values, for example, may go unnoticed until communication is attempted. Communication may also have the effect, intended or unintended, of obscuring and confusing existing problems.

. . . . In short, the advocacy of communication needs to be qualified with respect to the kind of information relevant to the solution of given problems and with respect to the nature of the communication process between individuals, between groups, and between subsystems.

(p. 223-4, underscore added)

The two dimensions of social organization--the networks of social relations and the shared orientations (in the quote from Blau and Scott, 1962, p. 4)--are often referred to as the social structure and the culture, respectively. Kroeber and Parsons (1958) define culture as "transmitted and created content and patterns of values, ideas, and other symbolic-meaningful systems."

England (1967) provides the following reasons for studying the values of managers in industry. They apply equally well to engineers and scientists in R&D:

1. Personal value systems influence a manager's (engineer's) perception of situations and problems he faces.
2. Personal value systems influence a manager's (engineer's) decisions and solutions to problems.

3. Personal value systems influence the way in which a manager (engineer) looks at other individuals and groups of individuals; thus they influence personal relationships.
4. Personal value systems influence the perception of individual and organizational success as well as their achievement.
5. Personal value systems set the limits for the determination of what is and what is not ethical behavior by a manager (engineer).
6. Personal value systems influence the extent to which a manager (engineer) will accept or will resist organizational pressures or goals. (p. 54)

One of the consequences of the values held by managers in organizations is their effect upon the choice of corporate strategy. Guth and Tagiuri (1965) state that:

Some managers may feel that their choices of corporate strategy are entirely objective. This may well be so if they include their personal values among the elements they take into account in their analysis and decisions. For it is quite clear, on the basis of observation and of systematic studies of top management in business organizations, that personal values are important determinants in the choice of corporate strategy. (p. 123)

They explain the process by which values affect strategy in the following manner:

The process by which an individual's concept of or feel for his company's strategy is formulated includes assessment of environmental opportunities and risks and of company resources. Such an assessment results in reasoned or intuitive judgements as to what the company might achieve and become over certain periods of time if it operates in certain particular ways. The individual's system of values is then applied to these judgements, and a choice among the alternative strategies is made. (p. 127)

But the effect of an individual's values upon his behavior is not always evident to himself. Nevertheless, they affect his actions. "If he is not very conscious or articulate about his personal values, they will impose themselves no less forcefully on his actual choices, i.e., those evidenced by his behavior." (p. 127)

Lawrence and Lorsch (1967a, p. 33), make a similar point. In discussing the "orientations to time" of respondents in their study as contrasted to other orientations, they note that these other orientations operated more outside the awareness of the members of the organization. This point is important to this study where we are concerned with the effects of work-related values on the



communication between technical groups. The mechanism by which values affect decisions--not only decisions about task content, but also about what to communicate and when--as explained by Guth and Tagiuri need not be one of conscious awareness. Values underly the behavior of people as individuals and in groups.

A variety of definitions of value and value system are given in the literature. England (1967, p. 54) offers an explanation that frequently appears:

A personal value system is viewed as a relatively permanent perceptual framework which shapes and influences the general nature of the individual's behavior. Values are similar to attitudes but are seen as more ingrained, permanent, and stable in nature. Likewise, a value is seen as being more general and less tied to any specific object than is the case with many attitudes. 'Value' as used here is closer to ideology or philosophy than it is to attitude.

Here we shall view a value as a "conception, explicit or implicit, distinctive of an individual or characteristic of a group, of the desirable which influences the selection from available modes, means, and ends of action." (Kluckhohn, 1951). Work-related values are those values particularly relevant to the individual as he performs his work in an organization including those values which are relevant to his profession.

The values of an individual, a group, an organization, or a society are not fixed. They evolve with time, affected by a variety of processes. March and Simon (1958, p. 65) observe that:

Humans, in contrast to machines, evaluate their own positions in relation to the values of others and come to accept others' goals as their own. In addition, individual members of an organization come to it with a prior structure of preferences--a personality, if you like--on the basis of which they make decisions while in the organization. Thus, individual goals are not 'given' for the organization, but can be varied both through recruitment procedures and through organizational practices.

With respect to the relation of values to the individual, his personality, and one aspect of change, Guth and Tagiuri (1965 ) comment:

Values are closely related to personality; indeed, they are part of it. If we say that a man decided among alternatives on the basis of whether the choice will maximize his usefulness to others, rather than on the basis of considerations of personal gain, we are describing his values as well as his personality. Values can be thought of as the guidance system a personality uses when faced with a choice among alternatives. They are very stable features of his

personality, especially if some values clearly dominate over others. (p. 125)

They go on to note that while some values may be stable, a person's system of values can still change:

Values may be identified by noting differences between individuals or groups in dealing with similar problems. Naturally, not all differences can be accounted for by variations in values; for instance, some variations are produced by differences in the accumulated knowledge and intellectual skills. Yet there appears to be an interdependence among knowledge, skills, and values. Sometimes, a change in the first two will lead to a change in the third.

Not only do values influence behavior, they also influence perception (cf., Postman, Bruner, and McGinnies, 1948) as illustrated by the common expressions, "he sees what he wants to see," "he hears only what he already agrees with," and "you can't teach an old dog new tricks."

#### 3.4.2 - The Acquisition of Values

One's values are acquired primarily during his early life as a child, in the process of his education, and during the early part of his career. Schein (1967) has studied the changes of attitudes and values of students during management education programs at MIT, and notes similar studies in fields such as medicine, dentistry, and law in his article. Krulee and Nadler (1960) have obtained measures of the long-range values and aspirations of engineering and science students at Case Institute of Technology. Schein notes that "It is assumed that the relevant attitudes and values are learned by the student during professional education; indeed, the concept of the professional school implies that the 'correct' professional attitudes be taught." He then addresses himself to the issue of whether a given school teaches the attitudes and values that prevail among practitioners at the time, or whether it attempts to induce change by redefining the attitudes and values the faculty sees as relevant for the future. Krulee and Nadler found that:

(A) major difference is revealed in the values attributed to organizational and administrative skills. The science students place greatest reliance on personal ability and rate as relatively unimportant the variety of skills that concern understanding people, being able to persuade, or to get people to like you. . . . The engineering students place greater emphasis on these interpersonal and administrative skills,

while the students of management view interpersonal and administrative skills as major determinants of their future success.

While there was a noticeable difference between what the students' ideally valued in their future and what they actually expected, the latter was realistically congruent with the nature of their chosen careers. In connection with the relationship between the students' career values and the faculty's, the following passage is of interest:

When students view their curriculum, they appear to want to "play it safe" and to hope for a program that will be a compromise between their desires and their expectations. They want some preparation for the more desirable outcomes in which innovation will be possible and problem-solving skills will be of high value. They need, however, to be reassured that they will also be prepared for less desirable possibilities and that their education will not render them unfit for success in these more numerous, less challenging, and more realistically obtainable positions.

Under these circumstances, it is not surprising that many students are uneasy about the increasing emphasis on analytical skills, nor that they expect that insufficient time will be given to the development of their administrative abilities. Is it not also possible that the students view their faculty as insufficiently aware of the nature of the career gamble that the students are preparing to face? The faculty would appear to plan as if the desirable outcome were the only alternative and to ignore some less desirable possibilities that the students evaluate as highly realistic.

(p. 158)

The process by which the newly hired engineer or scientist learns the values of an organization has been reported in several studies. This process is variously termed "socialization," "acculturation," "enculturation," "learning the ropes," etc., depending upon one's background and predilections.\* Marcson (1960a,b) conducted an interview study in the central laboratory of a large electronics company on problems in recruiting and integrating scientists into the laboratory. With respect to the scientists, he notes that:

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\* Utterback (1965), in his study relating enculturation and other factors to idea flow in a research laboratory, provides the following list of terms all closely related to learning the values and norms of an organization: socialization, acculturation, internalization of norms, normative control, fusion, accommodation, and identification with the organization.

The laboratory attempts to pull the recruit into its value system and redirect his research interests. . . . From the point of view of the laboratory, the problem is one of broadening the interests of the recruit and developing a devotion to the goals of the laboratory organization. From the point of view of the recruit, the problem is one of broadening the interests of the laboratory and developing a devotion to the goals of science. (1960a, p. 164)

This process of internal change for the scientist is felt by him and the laboratory as a strain, a conflict in values.

Avery (1960), on the basis of 110 interviews in ten industrial laboratories, discussed the process of "enculturation" by which the young scientist or engineer comes to understand what a laboratory needs or wants--what its values are in terms of technical ideas. Emphasis is placed on the factors influencing the kinds of ideas he produces and how he handles these ideas. "In some fashion every researcher gradually constructs what might be called a mental map of his organization." This map helps him in manifold ways concerned with getting information and producing and communicating relevant ideas congruent with the evaluations that others will make.

Kornhauser (1962), in his study of conflict and accommodation of scientists in industry based on interviews in nine laboratories, has also been concerned with the establishment and maintenance by a group of a reasonably uniform set of values. He finds that "Scientists naturally strive to present problems which will be accepted," and in order to do so they must come to learn the values that are applied in making such decisions.

Another study of the enculturation process and the effects of initial job assignments is given in Schein, McKelvey, Peters, and Thomas (1965) and Schein (1964). LaPorte (1965, 1967) focusses on the environment of organized research and the problems or points of tension that occur between technical professionals, managers, and customers. He considers the value differences of the professionals and managers and then focusses on several mechanisms which often develop to reduce the manifest conflict to a manageable and generally latent level.

### 3.4.3 - Values of Engineers and Scientists

The values of engineers and scientists have been considered from a variety of standpoints. There are those values associated with employment in general--values of the individual in terms of his career and his relationship to other individuals in his working group; values associated with professions and professionals; values of science; and those values that enter into the discussions of the conflict between the values of the professional working in government or industry and the values of his organization. In this section we shall briefly consider some of the values that are considered in these various contexts, beginning first with the value of work itself.

In discussing the organization theory developed by her colleagues [Trist, et al, (1963)] Bucklow (1966) states that "The concept that integrates the technological, economic, and socio-psychological aspects of a production system is the primary task: the work it has to perform. Work is the key transaction which relates an operating group to its environment and allows it to maintain a steady state" (p. 72). Considering that the work is performed by individuals, work itself is valued by them. But for the person in our society today, one must inquire more closely. Rosenberg, et al, (1958) related the career aspirations of college students to their values, and conducted other studies of career choice and values.

These items were used by Marsh and Stafford (1967). They tested the hypothesis that attitudes toward work--namely "professional and intellectual values" as contrasted to "acquisitive values"--can be considered to measure compensation for earnings forgone by choosing an academic career rather than a career in industry. Data on earnings, the Rosenberg, et al, (1958) work values scale, and other conditions of work were obtained from 51,905 members of the U.S. professional and technical work force. They found that "professional values are related to the choice of academic employment as mediated through the process of educational attainment" (p. 748), and that, "academicians in fact earn less, have different (more professional) attitudes, and, on the behavioral side pursue work activities with a somewhat smaller pecuniary return. ... non-monetary income, as measured by the values relating to work and work content, provides compensation for the strictly monetary 'losses' of the academicians. . ." (p. 752). The items they used in their work values scale are listed below. They found that the pattern of their intercorrelations formed two clusters which they called

"professional" and "acquisitive." Two items did not show any coherent inter-correlations. The "professional" values were:

- Opportunity to be original and creative.
- Relative independence in doing my work.
- Freedom from pressures to conform in my professional life.
- Freedom to select areas of research.
- Opportunity to work with ideas.

The "acquisitive" values were:

- Opportunity to work with people.
- Pleasant people to work with.
- A chance to exercise leadership.
- A nice community or area in which to live.
- Social standing and prestige in my community.
- A chance to earn enough money to live comfortably.

The remaining two items were:

- Opportunity to be helpful to others or useful to society.
- Opportunity to work with things.

Krohn (1960, 1961) studied the effects of the institutional location--industry, government, or university--of scientists upon their scientific attitudes and values. He interviewed a random sample of approximately 30% of the working scientists in the Minneapolis-St. Paul area and based his findings on the scales given below. These scales indicate several values applicable to the scientist. One of the points that Krohn was particularly interested in was the scientists orientation towards the traditional notion of individual research vs. team research efforts. He found that "The industrial and governmental scientists showed less agreement with the traditional conception of science and of the scientific role than their colleagues in the University" (1960, p. 228), and also that there was a lack of science performed using teams in that area (p. 223). His scales were as follows (1961, p. 134-5):

A. On the Conception of Science:

1. Knowledge-Utility Scale. A measure of the degree to which science is legitimized by appeal to the value of knowledge or to that of utility. (10 items.)
2. Theory-Method Scale. A measure of the degree to which essential importance in the research process is attributed to creative thought or to rigorous methodology and advanced technology. (5 items.)
3. Personality-Situation Scale. A measure of whether discovery is attributed to the creative personality or to appropriate research conditions. (6 items.)

B. On the Nature of the Scientific Role:

4. Intellectual-Professional Scale. A measure of whether the scientific role is seen to be essentially

that of an independent intellectual or that of a professional employed for his skills and knowledge. (10 items.)

5. Private-Organizational Motive, Abstract Scale. A measure of the degree to which scientific work in general is seen to be the result of purely private motives (curiosity, etc.) or to be the result of working for satisfactions that are organizationally mediated (salary, prestige, etc.). (8 items.)

6. The Private-Organizational Motive, Personal Scale. A measure of the degree to which the scientist evaluates his own job as an opportunity to gain private satisfactions (learning, satisfaction of curiosity, freedom etc.) or as an opportunity to gain organizationally mediated satisfactions (salary, promotion, prestige, etc.). (15 items.)

C. On the Appropriate Organization for Scientific Research:

7. Individual-Team Scale. A measure of the degree to which the most productive unit of organization of research is considered to be the individual investigator or the organized research team. (4 items.)

8. Freedom-Bureaucracy Scale. A measure of the degree to which the most important quality of the administration of research is considered to be freedom for the individual or efficiency for the organization. (5 items.)

In a questionnaire study of work alienation (roughly, lack of pride in one's work and lack of opportunity to work on what one can take pride in) among 419 professionals in a basic science laboratory and an aerospace division of one company, Miller (1967) found that, "Alienation from work was more strongly associated with type of supervisor and degree of company encouragement among scientists and professionals with advanced training than for engineers and professionals with less advanced training. Freedom of research choice and professional climate were strongly associated with work alienation for all professionals. Moreover, [contrary to his expectations] these relationships remained strong when length and type of professional training were controlled" (p. 767). These findings give some insight into the importance that engineers and scientists may give to values associated with the opportunity to choose what they will work on and to "professional climate" which Miller measured in terms of "1) freedom to publish the results of their research, 2) funds for attending professional meetings, 3) freedom and facilities to aid in their research, 4) promotion based on technical competence, and 5) opportunities to improve their professional knowledge and skills" (p. 759).

Hagstrom (1966) stresses recognition as an important motivation of research scientists--important enough to cause them to sacrifice income for its sake.

Kornhauser (1962) argues that the scientist's professional concern with technical and scientific competence overshadows the typical rewards of industry attained through promotion and status. In a study of a university-based R&D group of engineers, Shepard (1954, p. 458) found that, "Income as a measure of value was rejected, and official titles were rejected as measures of status." The valued reward came from the project itself; it was an opportunity to learn.

As a part of an interview study of 209 technical researchers considered by managers in industrial firms to be creative, Jones and Arnold (1962, p. 54) found that these respondents considered the following (in rank order) the most important things management could do "to stimulate creativity among research staffs." A number of them indicate the work-related values of these researchers who are considered to be creative:

- 1) Positive recognition of creativity and productivity from management and rewards for individual achievement.
- 2) Positive attitude of management toward research and development activities.
- 3) Opportunity to work with other creative people.
- 4) Personal freedom in selecting research projects and techniques.
- 5) The challenge of working on important problems.
- 6) Freedom from excessive supervision of projects.
- 7) Well-defined company and research goals.
- 8) Freedom to complete problem assignments.
- 9) Company assistance in personal development.
- 10) Management support in writing and publishing articles.
- 11) Technicians to perform routine jobs.
- 12) Free and effective communication between all levels.
- 13) Quality of the equipment and facilities.
- 14) Outside contacts with professional colleagues.

Pelz and Andrews (1966) in their questionnaire survey of the motives of 1311 scientists and engineers in eleven R&D laboratories were concerned with the motives and values of these researchers and the relation to their productivity. They obtained a measure of the following work-related values in response to the question, "Listed below are different kinds of opportunities which a job might afford. If you were to seek a job, how much importance would you personally attach to each of these (disregarding whether or not your present job provides them)?" (p. 121):

- To make full use of my present knowledge and skills.
- To grow and learn new knowlege and skills.
- To earn a good salary.



- To advance in administrative authority and status.
- To associate with top executives in the organization.
- To build my professional reputation.
- To work on difficult and challenging problems.
- To have freedom to carry out my own ideas.
- To contribute to broad technical knowledge in my field.
- To work with colleagues of high technical competence.
- To have congenial co-workers or colleagues.
- To work on problems of value to the nation's well being.
- To work under chiefs of high technical competence.

Merton (1957) developed, on the basis of prior philosophical and historical writings, four basic mores of science: universalism, communism (in its broad sense, sometimes called "communality"), disinterestedness, and organized scepticism. Universalism refers to the assumption that physical laws are everywhere the same while the truth and value of a scientific statement is independent of the characteristics of its author. Consequently, empirical knowledge cannot be rejected for national or political reasons. The basis for judgement is the evidence, not the man. Communism or communality refers to the open sharing of knowledge. New knowledge gained in the pursuit of science belongs to the community of science, not to the individual for his personal gain. From this derives the norm that new findings are to be published in order for them to be evaluated and the creativity of their originator to also be evaluated. Disinterestedness prohibits the scientist from making the search for professional recognition his explicit goal. "The translation of the norm of disinterestedness into practice is effectively supported by the ultimate accountability of scientists to their compeers" (p. 559). To this norm, Merton attributes the noticable lack of fraud in science as compared to other areas of life. Organized scepticism refers to the detailed scrutiny of beliefs in terms of empirical and logical reasoning. Each scientist is individually responsible to ensure the validity of previous research done by others. The scientist is obligated not only to doubt his own findings, but also to make public his criticisms of the work of others.

Beginning with these four mores or norms of science, Hill (1967) developed a set of values as derived from these and related considerations:

It would be expected that high value would be placed on truthfulness, conscientiousness, self-discipline, objectivity, creativity, and perhaps scientific curiosity, as these are basic to the process of scientific research itself. In relation to the norm of "universalism," value would be placed on total equality of scientists without

regard to political or national bias. With respect to "communism," high value would be expected on publication (and consequent interaction with the social system of science) and rejection of secrecy for personal gain. From "disinterestedness" would be derived a higher value on dedication rather than ambition, and a rejection of the drive for personal profit from research; value would also be placed on tolerance of opposing viewpoints, for again, lack of tolerance would involve promotion of self at the expense of rational evaluation. "Organized scepticism" would generate a high value on critical evaluation of all scientific opinion no matter what its source, and on independence of action. "Emotional neutrality" would suggest a value on flexibility and a certain emotional detachment particularly in the face of rational criticism. A high value would also be placed on "humility" with respect to scientific claims. Finally, the "welfare-mores" of science, or "other-orientation" as Barber (1953) terms it, suggest that a high value would be placed on the contribution scientific research can make to mankind, i.e., on a sense of science's mission. (Hill, 1967, p. 83-4)

Hill stresses that these values represent a "philosophic interpretation" of the ideal role of the scientist. He later categorizes these values in terms of their relevance with the process of research in the context of industrial organizations as follows:

Values basic to the process of research

- Creativity
- Objectivity
- Truthfulness
- Scientific curiosity

Values contributive to successful research

- Persistence
- Independence
- Flexibility
- Subjective insight

General values of the social system of science

- Non-influence of subjective factors in judgment of scientist contribution
- Communality of scientific knowledge
- Dedication rather than ambition
- Sense of science's mission

Personal-oriented values supportive to research in industrial groups

- Emotional neutrality
- Tolerance
- Personal scepticism

General orientation of work-approach

- Academic orientation
- Application orientation
- Compromise rather than exhaustive research

Hill also developed a set of interpersonal behavior values for use in the portion of his study dealing with the relationship of values to the internal structure of R&D groups (considered later in this chapter). They are:

Values contributive to task

Sincerity  
Conscientiousness  
Intelligence  
Self-discipline  
Imagination  
Enthusiasm

Values contributive to a non-involved social atmosphere

Sense of humor  
Understanding, sensitivity  
Interest in people  
Unselfishness  
Sociability  
Modesty

Group-oriented values

Promotion of group welfare  
Conformity  
Individualism  
Ability to lead and control

Personal-friendship oriented values

Seeking of personal friendships  
Similarity in interests: religious, political  
Similarity in interests: sports, hobbies

Perrucci and his associates have been engaged in a study of the development of engineering as a profession (Perrucci, LeBold, and Howland, 1966). Perrucci (n.d.) provides an empirical assessment of the concept of professionalism by examining several dimensions of professional values and behavior as reported by a sample of approximately 3400 engineers from 150 organizations. He notes that, "At the most general level of findings it appears that professionalism is a multi-dimensional concept in both the value and the behavioral sense, and that there is only a modest association between professional values and behavior" (p. 21). He found that colleague contact, professional community, and knowledge production and dissemination were the most central professional values and suggests that they are the most salient components of professionalism among engineers. The dimensions of professional values that he identified and the items comprising them are as follows (pp. 7-8):

Work challenge

To have an opportunity:

1. to innovate and propose new ideas.
2. to use my skills and abilities in challenging work.
3. to work on problems for which there are no ready-made solutions.
4. to see my ideas put to use.

#### Career advancement

To have an opportunity:

1. to advance myself economically.
2. to enhance my social status and prestige.
3. to have a clearly visible line of increasing rewards and promotions.
4. to be able to advance and move ahead in my position.
5. to move into a management career.

#### Autonomy

To have an opportunity:

1. for a position which leaves me relatively free of supervision.
2. to make most decisions connected with my work.
3. for a large degree of freedom to manage my own work.
4. to fix my own work schedule so there aren't excessive demands on my time.

#### Colleague contact

To have an opportunity:

1. to associate with other engineers and scientists of recognized ability.
2. to present and discuss my ideas with colleagues.
3. to have the respect of my colleagues because of my technical achievement.
4. to work with colleagues who are interested in the latest developments in their field.

#### Professional community

To have an opportunity:

1. to be a member of a professional community outside of the particular place I am employed.
2. to be treated as a professional by my superiors and higher management.
3. for membership in an organization that is highly regarded by people in my profession.
4. to have time for outside professional society work.

#### Contribution to knowledge and society

To have an opportunity:

1. to be free to publish non-confidential scientific findings.
2. to contribute to basic scientific knowledge.
3. to make significant contributions to society.

The effort required to translate research findings into practical devices and applications requires attention to many major problems and an exceedingly large number of small problems, many of which if unresolved will lead to inadequacy or failure in the end product. Additionally, much of the work of industrial R&D is less concerned with the direct translation of new scientific knowledge into new products than it is with new innovations that are the result of new variations on old principles. It would appear that industry and society in some

sense are limited in the amount of basic scientific discoveries that they can, or are willing to, absorb in any given time. One result of these considerations is that the number of engineers far exceeds the number of scientists in government and industry. Yet considerable theorizing and empirical studies have been built around the concept that there is an inherent tension between the "professional" (the scientist) in industry and the organization (cf., Gouldner, 1957; Marcson, 1960; Kornhauser, 1962). Goldberg, Baker, and Rubenstein (1965) characterize this conceptualization as follows:

On the one hand, there are the cosmopolitans (or professionals, etc.) who are oriented toward seeking status within their professional group, who have a deep commitment to their specialty, who are strongly committed to their distinctive professional ideology, and who seek the approval and recognition of peers outside the organization as well as within it. On the other hand, there are the locals (or organizationals, etc.) whose primary loyalty is to the organization for which they work, who seek advancement up the managerial hierarchy, who identify with the organizational goals and values, and who seek recognition primarily from organizational superiors. ... [Various writers, cf. above] have viewed the goals and expectations of professionally oriented and organizationally oriented research as standing in sharp contrast to each other and have considered research staffs to be internally divided between those who are interested in management promotion and those who are interested in research achievements that will bring professional recognition. (pp. 704-5)

They provide evidence indicating that these two types of value orientations are not polar, but rather are independent of each other. A researcher can be both committed to research and yet value the organization and its rewards. This does not negate the observation that there is tension, but it does indicate that these values are not in opposition to each other. While the issue is not yet settled (and is not addressed by the present study) it does point to the considerable emphasis that exists in the literature on the values of science and scientists in contrast to the few studies on the values that characterize engineering and engineers. The social scientist, it would appear, has tended to assume that all of the work of R&D is distinctively characterized by the norms of science as expressed in the "philosophical" literature. Further exploration of work-related values, including values perhaps distinctive of engineering as well as the values of science and interpersonal values, is required. Such values are included in this study. The items from which they were developed are presented in Chapter 4 and the categories are developed through the analysis given in Chapter 5. The primary use made of these values is to determine the effects of similarity and differences in values between pairs of working groups upon the problems in communication that the group members' experience.

### 3.5 - EFFECTS OF SIMILARITY OF VALUES

In the "Idea Flow" ~~study~~ of the Program of Research on the Management of Research and Development, as outlined in Chapter 1, one of the factors of principle concern was the communication of ideas for new projects from researchers to decision makers. One of the important aspects of this process, as described by Pound (1966) and as implied in Siegman, Baker, and Rubenstein (1966) and Baker, Siegman, and Rubenstein (1967), are the values of the researcher and the people to whom he could or does communicate his ideas. The values of interest in these studies were those used by the individuals to determine the relevance of an idea for a project and to decide whether or not work on the project should be performed. Theory concerning both the similarity of the values of the researcher and the recipient of his ideas, and the perceptions of the researcher of the recipients' values were investigated by Pound.

In this study we are concerned more broadly with the communication of all types of technical ideas, problems, and other information between individuals and technical groups, rather than with just the communication of ideas for new projects. However, the treatment of the theory by Pound is equally applicable, for the most part, to other aspects of the effects of value similarities or dissimilarities on the communication between technical groups. The material in this section follows much of his development with suitable additions and modifications where required.

#### 3.5.1 - Value Similarity and Interpersonal Attraction

Much of the literature concerned with the effects of similarity concerns the relationship of similarity between two entities, usually persons, and attraction to the other, or "liking."

Newcomb (1961) studied for a year two groups of college students who were living together. He traced the patterns of interaction and relationships as they developed over this period. He found that the stronger a person's attraction to another, the more likely he was to perceive that their attitudes would agree on relevant and important matters. Among pairs, it was found that as individuals came to know each other, a positive relationship began to develop among those who had high attitude similarity before becoming acquainted. Thus similarity can lead to attraction. Presumably, and we shall later present some evidence on

this point, it would also lead to reduced problems in communication being perceived between the members of the pair.

Thibaut and Kelley (1959) have developed a theory of interpersonal relations based on intra-individual rewards and costs as measured relative to a "comparison level." They suggest the following explanation in response to the question, "Why is value similarity an important factor in friendship development? The answer may be stated in terms both of ability to reward each other and the cost of providing this reward. If we assume that in many value areas an individual is in need of social support for his opinions and attitudes then another person's agreeing with him will constitute a reward for him. . . . Thus two people with similar values may provide rewards for each other simply by expressing their values," (p. 42) Further, "If we assume that similarity with regard to values operates to reduce cost and/or heighten reward, then relationships maintained over great distances would be expected to show relatively high value similarity." They cite a study by Williams, et al, (1956) that provides support for this.

Heider (1958) has developed a theory of "cognitive balance" which can be applied to the similarity phenomenon. When the entities are persons and they feel similarly about each other, the persons are in a balanced state; if one feels positively about the other and the feeling is not reciprocated, a state of imbalance is said to exist. One implication of Heider's theorizing is that for any two persons who see themselves related in any way, the balanced state will be one in which both partners feel mutually attracted or unattracted to each other. A second implication is that persons who are similar to each other will be more attracted to each other. Marlowe and Gergen (1969, p. 626), in their review of personality and social interaction, note that the evidence for a positive correlation between similarity and liking is voluminous and cite twelve references as examples including both laboratory and field studies such as Newcomb (1943) and Precker (1952b). Such studies include correlations of attraction with similarity in personality traits, demographic characteristics, attitudes, interests, and values. Precker's study concerned values of faculty and students; Hill (1967) also found similar results for researchers in their R&D groups.

In attempting to understand and explain observed communication patterns, perhaps the single area which has been studied the most extensively is the similarity between individuals. Katz and Lazarsfeld (1955, p. 44) theorize that:

Interpersonal relationships seem to be 'anchorage' points for individual opinions, attitudes, habits, and values. That is, interacting individuals seem collectively and continuously to generate and maintain common ideas and behavior patterns which they are reluctant to surrender or modify unilaterally.

This suggests the existence of a relationship between interaction and similarity. However, as these authors later point out (p. 59), it is difficult to determine empirically whether similarity or, more precisely, value similarity precedes or follows interaction. Communication may lead to value similarity or vice versa; it is not clear which.

Similarity of values is defined here as the degree to which the importance attached to certain work-related values by one person or group corresponds to the importance attached to the same values by another person or group.\*

While much of the literature, as noted, deals with the relationship between similarity and interpersonal attraction, the following passage more directly indicates an association between similarity of values and communication:

All behavior can be viewed as involving an evaluational element--that is, it can be investigated as manifestations of the valuing process. Valuing operates in the selection of associates, it is here suggested, since they allow for a universe of discourse, an operational "language" which facilitates intercommunication and thereby, interaction.

(Precker, 1952b, p. 406)

Pound (1966) makes several observations on this. Precker's statement indicates that values which are important to the nature of the communication are those that primarily influence the choice of recipients. This implies that similarity in work-related values is likely to be a more important determinant of task-related communication patterns than other values, such as the religious, political, and aesthetic values of the Allport-Vernon-Lindzey (1960) scale of values. Precker's comment on the possibility of viewing all behavior as involving an evaluation element is related to the communication/decision making process or organizational functioning described earlier. Precker also implies that similar values facilitate communication by helping to establish a common language, or more likely, common meanings contained in the implications of the information exchanged. March and Simon (1958, p. 167) state that, "The

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\* This corresponds to the definition given by Pound (1966, p. 45) for "agreement on criteria," which, in turn, is based on a definition given in Gage and Exline (1953, p. 382).



possession by two persons, or two organizational units, of a common, efficient language facilitates communication. Thus, (communication) links between members of a common profession tend to be used in the communication system."

The dependent variable in Precker's study was the choice of an advisor or student. He found statistically significant support for the propositions: 1) Students tend to select associates with similar values in an area of their functioning, where greatest similarity of values tends to occur when reciprocal choices are made. 2) Students tend to choose advisors (in a free choice hypothetical situation) whose values (related to educational evaluation criteria) resemble their own: 2A) Greatest similarity of values tends to occur when real advisor and advisor-choice are the same person. 2B) Seniors tend to choose advisors whose values are more similar to their own than do freshmen. Precker did not investigate the effect of values on communication, per se.

### 3.5.2 - Value Similarity and Communication

Experiments and some field studies have been done on the relation of cognitive structures to communication. Cognitive structures are measured in terms of the number, variety, complexity, etc., of categorizations of various objects (such as a formal organization, as mentioned below). Runkel (1956) in a classroom situation found that students received higher grades on quizzes when they were "cognitively similar" to their instructors. The differences between the similar and non-similar students could not be accounted for by differences in intelligence, conformance to common attitude norms, nor by preferences for the same stimulus statements (p. 191).

The work of Osgood, Suci, and Tannenbaum (1957) on the measurement of meaning through the use of the semantic differential technique, can also be interpreted as indicating differences in cognitive structures associated with the same concept--such as an adjective or noun--that will affect accuracy of communication. In Triandis (1959) study of "categoric similarity" in an industrial firm, he found that superior-subordinate pairs communicated more effectively when they similarly categorized particular people. "The more similar the categories of thought employed by two people, the more likely it is that they will communicate and the greater the likelihood that they will like each other."

In a second study, Triandis (1960) tested the proposition that pairs which are

cognitively similar exhibit greater communication effectiveness. He did this by analyzing the words used by the subjects to describe the characteristics of selected pictures--the basis of an attribute similarity measure--and analyzed the words used in messages sent between the separated members of each pair as they attempted to determine what picture they held in common--the basis of a communication similarity measure. Communication effectiveness was measured by how close each pair came in a limited time to identifying the picture they held in common. Both measures of similarity were correlated highly with the measure of communication effectiveness (0.83), but were only moderately correlated with each other (0.34).

Zajonc and Wolfe (1963) tested a proposition with the underlying assumption that "different opportunities for information processing (would) result in different organization of cognitive content represented by the cognitive structure," (p. 23) and that different organizational positions would provide different information processing demands and opportunities. Cognitive structures were found to vary with the position of the individual in the company (but this result has to be interpreted with caution because differences in educational background varied in a similar manner). They also offer a comment that is appropriate to the effect of values, as well as the effect of cognitive structures, on communications: ". . . (I)ndividuals who have different histories of communicational involvement and therefore different histories of information received, processed, and transmitted, will in general have different cognitive structures. Since we take the components of the cognitive structure to represent traces and effects of information processed in the past, we should expect that individuals having a restricted communicational history will cognitively differ from those having a rich communicational history" (p. 12). While they do not consider the work-related values of individuals, it would appear that values would affect the structuring of cognitions, as well as one's values being affected through the process of enculturation by his position in the communication network of the organization.

Lerner and Becker (1962) investigated the relation between value similarity and choice of person towards whom communication is directed as a function of the communication situation. They found support in a study of student behavior for the following propositions:

1. An individual will prefer to interact with someone who is perceived as similar rather than different if the situation

of interaction is such that it allows mutual gain.

2. An individual will prefer to interact with someone who is perceived as different rather than similar if the situation of the interaction is such that it will result in gain for one at the expense . . . of the other.
3. An individual will choose to communicate with the similar other if the situation does not compel the individual to persuade the other.
4. An individual will choose to communicate with the different other if the situation does compel the individual to persuade the other to agree.

The first hypothesis received the strongest support. Outside of the psychological laboratory and in the R&D laboratory where the choices of who one does or can communicate to are more constrained, these propositions suggest the content and timing of communications may be affected, as will be discussed below.

Mellinger (1956) studied a group of 330 professional scientists. He found a "moderately positive" relationship between agreement and communication, although this relationship was found to depend upon liking, and to a lesser extent upon trust. An individual who lacks trust in the person to whom he communicates tends to conceal his own attitudes, resulting in messages which are "evasive, compliant, or aggressive" (p.309).

Shepard (1954) did a case study of a project team composed of several sections in a university-sponsored laboratory. Based on interaction counts and interview data, he found considerable interaction at all levels within and between the sections, with the rate greater within than between sections. "Project problems were a favorite topic in casual conversations, informal sessions, and at lunch as well as at more formal conferences." The members of the project identified themselves with the project goal and saw good or improved communication as the means to that end. They described the structure of the project not in terms of the usual formal organization chart, but rather in terms of communication links and feedback paths, diagramming them in a manner similar to the systems they were working on. The values that they shared and that were reflected in their behaviour and descriptions were not the values upon which the administrative organization of the laboratory was based. "Income as a measure of value was rejected, and official titles were rejected as a measure of status. . . . The authority to proceed along certain lines was not thought to derive from organizational title, but from having enough information to make correct decisions." Shepard found that the most valued reward offered by the project,

and that to which the staff was responding was the opportunity to learn. "A member's ability to provide useful technical information was a measure of his social worth in a group that sought technical competence." This orientation toward the laboratory provided a basis for collaboration. "The laboratory was often referred to as a 'supergraduate school.' . . . Essentially the same values were adopted as those justifying the educational period of life . . ." These values and their effect upon the importance of task-oriented communication

. . . can also be understood in the light of the definition of the laboratory as a supergraduate school. To prepare for the jobs they anticipated, members sought competence in all aspects of control-systems research. Hence the engineer trained in one field had an interest in becoming familiar with the other fields involved in this type of research. This interest encouraged collaboration. The emphasis was on mutual education. The rewards of participation in the project group were increased and broadened technical competence, and a reputation for competence.

One of the groups in the project was a test section which was located at a remote site. Communication between the test section and the other sections was much less frequent and suffering many complaints. The situation caused one test section leader to resign. He was replaced by a member from another section, but the complaints continued. "The new section leader then realized that members of the other sections did not fully comprehend test problems, so he invited them to participate in tests. As a result, the number of complaints was greatly reduced. However, as the project approached completion, the need for even closer liaison with the test section became greater, and finally to meet this need, other sections were moved to the test site."

Dominant value similarities were important in the functioning of the communication system of the project, but in the case of the test section additional information, probably some of it of a factual nature, possibly some of it related to values, was needed to facilitate the process.

In Pound's study (1966) of the idea flow process in R&D, he sought to relate the "agreement on criteria" for the evaluation of new project ideas to the proportion of ideas communicated to others. His results regarding the proposition that, "The greater the agreement on criteria between one individual and another in a laboratory, the greater will be the frequency of idea communication between them," are inconclusive because of difficulties in obtaining an adequate measure of the dependent variable. However, he did find that as one goes down the

laboratory hierarchy from director of research to engineers that the "general level of agreement on criteria uniformly decreases (with one possible exception)" (p. 224).

In addition to the comments made in connection with the Lerner and Becker (1962) study, we note Triandis (1960, p. 175) reasoning as follows:

To the extent that A and B are cognitively similar (orient towards significant aspects of their environment in similar ways) and there is an opportunity for communication . . . , communication should be rewarding, and interactions should lead to increased liking of A for B and B for A. Increased liking should result in higher rates of interaction between A and B and this, in turn, should produce greater cognitive similarity, thus starting the cycle all over again."

While the rate of interaction that Triandis focusses upon is a useful variable in a free choice situation, and is readily measured in the experimental laboratory, it would appear that it is but one of several closely related variables to which the same reasoning can be applied.

There is considerable evidence from the psychological literature that similarity between people in attitudes, values, and individual traits, is associated with liking. Much less has been done on the relation between similarity in these aspects of people and communication. However, some inferences are possible.

In the R&D work situation, one may not have a completely free choice in his associates, but oftentimes he does have some degree of freedom, and moreso when he leaves his own group to obtain or provide information to another group. Hence, there is some latitude for these postulates on interpersonal attraction to operate in terms of the choices one makes about who to communicate to or through. But given that who one has to communicate to is constrained by the situation, the individual still has control over a number of factors in the process. At least to some extent, he can control the frequency of the communication events he initiates, and by his responses he can affect the frequency of initiation by the other. He can also control what he says--he can give more or less information accurately or inaccurately. Most readily, he can control the timing--providing early indications of plans, likely outcomes, current progress, etc., or delaying transmission of necessary information.

This reasoning may be applied to the prior findings about similarity and liking to form the proposition:

The less the similarity of the work-related values between one individual and another, the greater the communication problems one will perceive in dealing with the other.

Rate of interaction, direction of initiation, and other variables of similar nature are subject to considerable inaccuracies when obtained from respondents memory or impressions in the field as Rubenstein (1953) has noted, but the perception of specific problems in communication will reflect the internal conditions under which the respondent is working and to which he responds.

In the working environment some modification of the proposition is required due to the constraints imposed by task interdependence. Berkowitz (1969, p.86) notes that

Sometimes a person helps other people, not [just] because he is reciprocating for past benefits or expects rewards from other people in the future, but because of incentives he provides for himself. Making this point in analyzing dependency, Berkowitz and Daniels (1963) contended that many persons in our society attempt to help others who are dependent upon them because such assistance is prescribed by a 'social responsibility norm.'"

Homan's (1961) concepts of "social exchange" and "distributive justice" also provide support for these contentions. They imply that in the task-relevant situation, but where there is low task dependence such as where one seeks advice or consultation from another, the information sought may be readily provided regardless of similarities or differences in work-related values. However, when task dependence is high, the information exchange process is likely to require more frequent occasions to communicate about matters more frequently important to the adequate work performance of one or both parties. This would also provide more opportunities to become aware of the work-related values implicit in the behavior and decisions of either party. If their values were similar, and accompanied by an adequate level of expertise, the resulting activities would lend support to the adequate activity performance of one or both. However, if the activities of one, in part resulting from the values that enter into their decisions, did not provide support to the activities of the other, this would become evident in communications between the two. Thus, at low levels of task interdependence, differences in work-related values are not likely to manifest themselves in perceived communication problems; but at high levels of task interdependence, they are more likely to be manifest and to have a greater effect upon the communication between the individuals or groups. Thus the proposition above is modified to:

Proposition Pl.1: For a given level of task interdependence perceived by an individual between himself and another person, the less the similarity of his work-related values to those of the other, the greater the communication problems he will perceive as existing between them.

This postulates that at low levels of task interdependence, the effect of actual similarity in values on perceived communication problems will be less severe or non-existent than at a high level of task interdependence.

Values are not a property of just the individual, as is apparent from discussion elsewhere in this chapter. Values extend from the individual to his culture (Kluckhohn, 1951; Williams, 1968; Albert, 1968). Studies of similarity and liking in psychology involving groups as the object to be judged appear to be relatively infrequent. A study of the effects of groups on impression formation is reported by Levy and Richter (1963). Studies involving groups are more common in anthropology. Several are cited by Campbell and LeVine (1968). The studies of African tribes analyzed by them provided support for the proposition that, "(F)rom the point of view of any ingroup, the more similar an outgroup is in customs, values, beliefs, and general culture, the more liked it will be." Applying the same rationale as before to relate "liking" and "communication problems," this suggests that Pl.1 will apply both for the individual with respect to another group, and for the groups of a pair with respect to each other, as in the following two propositions:

Proposition Pl.2: For a given level of task interdependence perceived by an individual between his working group and another group, the less the similarity of his work-related values to those of the other group, the greater the communication problems he will perceive as existing between the two groups.

Proposition Pl.3: For a given level of task interdependence perceived to exist between two working groups by the members of those groups, the less the similarity of the work-related values of the two groups, the greater the communication problems each will perceive as existing between the two groups.

### 3.5.3 - Value Homogeneity

Even though group members in an R&D laboratory may have been working together for a considerable period of time, the enculturation process would not necessarily have produced complete homogeneity in their values. Relatively "young" groups would likely not have very homogeneous values. Indeed, Pelz and Andrews (1966) in their study of 1311 engineers and scientists from eleven laboratories, anticipated finding better performance among scientists who were dissimilar to their colleagues. On the basis of mixed evidence they conclude, "Thus it appeared that some combination of similar and dissimilar characteristics in one's colleagues might be best [for individual performance]" (p. 145). Their proposition was based on an earlier study, Pelz (1956), which had shown that dissimilarity enhanced productivity. While productivity and communication need not necessarily be correlated, in parallel fashion the homogeneity of work-related values, or lack of it, may affect the communication process both within and, of interest here, between groups.

If we view groups as miniature cultures, then theories concerning ethnocentrism become relevant. Campbell and LeVine (1968) apply balance theory (e.g., Davis, 1963; Davis, in press) at the level of persons in clique formation to "ingroups" and "outgroups" in a culture. They propose: "Given that all persons have some negative and some positive interpersonal valences, and treating a pool of persons including ingroup and outgroup members, the following prediction results: The more mutual liking there is within the ingroup, the more ethnocentric the group will be, defining ethnocentrism for this purpose [related to other considerations in their paper] as degree of hostile attitudes toward outgroups." The hostility would arise because of perceived threats from other groups. Within organizations in a given culture, hostility becomes manifest in organizational forms of conflict and attendant communication difficulties as described by Walton's (1966) general model of interdepartmental conflict, which received general support in a number of its aspects in a study of six plants of a decentralized manufacturing firm (Walton, Dutton, and Fitch, 1966).

More relevant to our purposes are the following propositions Campbell and LeVine derived on similar grounds: "The more homogeneous the belief-systems of the ingroup members, the more homogeneously hostile toward outgroups will be these members. Internal agreement on belief systems represent parallel valuing of a large number of 'objects' or 'X's.' These parallel valuing induce



balancing positive interpersonal bonds. These intragroup bonds force all the hostilities [or likings] or negative [or positive] valencings by ingroup members (given that there are some) onto outgroup members [in our context, onto members of the other group of the pair] ." Applying the same reasoning process as before to again transpose from liking or hostility to perceived communication problems, we obtain the following proposition:

Proposition Pl.4: For groups with a high level of homogeneity in their work-related values, perceived communication problems with other groups will tend to be much better or much worse than for groups with a moderate degree of homogeneity in their work-related values.

This proposition concerning the effect of high intragroup homogeneity of work-related values also can be related to the following. Likert notes:

Work groups which have high peer-group loyalty and common goals appear to be effective in attaining their goals. If their goals are the achievement of high productivity and low waste, these are the goals they will accomplish. If, on the other hand, . . . (they) . . . reject the goals of the organization and set goals at variance with these objectives, the goals they establish can have strikingly adverse effects upon productivity. (Likert, 1961, p. 30)

High peer-group loyalty implies high attraction to group, i.e., cohesiveness, which Hill (1967) has shown to be related to value similarity within the group. So where the situation of an R&D group demands effective communication with another group for it to be productive, and they value being productive, it can be expected that they will work out some means to get around the communication problems they might otherwise experience. Thus, for groups with high homogeneity of work-related values, the level of communication problems would tend to be either distinctly better or distinctly worse than the level of communication problems of groups with moderate heterogeneity in their work-related values.

On the other hand, low homogeneity (i.e., high heterogeneity) of values could also be dysfunctional. For whatever reason that there was a large disparity, the studies reviewed earlier would imply that the attraction to the group would be relatively low. This would lead to problems of communication within the group and lack of understanding or agreement upon work activities. In turn, communication and coordination of their activities with other groups could be affected in a variety of ways--lack of

communication, long time delays in responding, frequent changes in plans or specifications, etc. This leads to the proposition that:

Proposition Pl.5: For groups with a low level of homogeneity in their work-related values, perceived communication problems with other groups will tend to be worse than for groups with a moderate degree of homogeneity in their work-related values.

### 3.6 - SOME ORGANIZATIONAL DESIGN ASPECTS

If research of this nature is to bridge the gap between the theories of psychology, sociology, anthropology, and other related disciplines and the needs of managers who must make decisions about how to manage, field tests of propositions specifically related to problems of organizational design are required. The persons in the best position to carry out such tests are the managers themselves. Managers are continually "experimenting" with their organizations. While they may very carefully plan out the changes--the "experiments"--they make, unfortunately they rarely do so in such a manner that one can be reasonably certain as to what caused the effects observed. The hypotheses of their experiments are left implicit, and the rival hypotheses also explaining the observed changes are many and their effects unaccounted for.

The propositions considered above deal with the effect of work-related values on the "effectiveness" of communication among R&D groups. They do not deal directly with organizational design issues, although they have direct implications for organizational design. Propositions derived from them--"organizational design propositions" (Rubenstein and Douds, 1969)--would be of direct utility to managers.

One of the functions of the design of an organization is to structure the communication patterns among individuals and groups. Much of the work of an organization, especially an R&D organization, is carried on through the exchange of information in communication among individuals and groups. A comparative study of both simple and complex organizations in several cultures indicates that work flow and the management processes by which it is controlled are fundamental in determining the relationships of organizational systems (Chapple and Coon, 1942). Chapple and Sayles (1961) argue that organizations can be designed

on the basis of work flow to minimize conflict between groups or managers and to enhance output. However, they primarily deal with production, order processing, and similar types of organizations.

In R&D organizations, the work flow consists primarily of information flow. At some points communication should be encouraged; at others it is desirable to limit it, i.e., Morton's discussion of "bonds" and "barriers" in his systems analysis approach to the design of R&D units (1964). As Morton implies, to have highly effective two-way communication among all points of an organization is not an undifferentiated good. If propositions P1.2 and P1.3 of this study are supported, then one criterion that would assist in determining where contact between groups should be limited would be the existence of a large disparity in work-related values between two groups. This suggests the proposition:

The greater the disparity in work-related values between functionally dependent work groups, the more contacts between the groups will tend to be restricted to a limited number of people and/or in frequency of contact, at a given level of functional dependence.

When the nature of their work is such that they are functionally dependent--but yet they have quite different values that they apply in making their task decisions, difficulties in communication could be expected. The organizational structure could be designed to take this into account. This frequently occurs at the departmental level and above where the boundaries between departments such as R&D, marketing, production, etc., are physically manifest by their location in separate areas, buildings, and so on.

The problem then becomes one of coupling the information flows of diverse groups together to provide effective joint output. One of the devices employed is to use some type of coupling activity--an individual "liaison man," or a special group, team or committee--to mediate the information flow or activities. Lawrence and Lorsch (1967) found some support for the proposition that "one partial determinant of effective integrative devices would be that the orientation of members of the integrative subsystem would be intermediate between those found in the subsystems they were to coordinate." Thus we might expect that

Individuals whose values are intermediate between two groups will be regarded as effective communicators with either group.

Another aspect of the coupling problem is the selection of personnel for such positions. Tagiuri (1965) found that the values of research managers, as

measured by the Allport-Vernon-Lindzey (1960) "Study of Values" questionnaire, were intermediate between those of executives and R&D personnel that the R&D managers were responsible for. (The data from the higher level executives and R&D managers were collected over a period of three years in management courses at Harvard. The executives were not those that the R&D managers reported to.) Tagiuri did not have a dependent variable in this report, but notes that "the conflict has been well documented [between] the managerial and scientific communities," citing four chapters in Hower and Orth (1963). His data also include perceptions of executives and scientists values by the research managers, and perceptions of the research managers values by the executives and the scientists. His data indicate that, whatever the behavior of the R&D manager is, its effect is to make scientists see him as an executive, and to make the executives see him as a scientist. "If the effective mediator needs to be perceived as having values common or intermediate to both the sides he represents, the Research Manager, while in fact possessing such intermediate values, is hampered in his work by being inaccurately judged." This would have a direct impact on the proposition above (and indicates the desirability of obtaining information about the perceptions of other's values). This also suggests that if the "mediating agent," coupler, etc., perceives the values of the group he is dealing with accurately, he will be able to communicate with them more effectively as in the proposition:

Individuals whose perceptual accuracy for another group's values is high will be regarded as effective communicators with that group.

In the next section we shall consider several propositions relating to the perceptions that individuals and groups may have of each other's work-related values.

### 3.7 - EFFECTS OF PERCEPTION

#### 3.7.1 - "Projection" Effects

In order for the effects of actual similarity of values to have the opportunity to manifest themselves, the people involved must have had some degree of contact with each other. This aspect has already been incorporated in the propositions, in part, by including the perceived level of task interdependence. However, it may not be the actual similarity or dissimilarity of values that matters as much as the perceived values. As Leavitt notes:

To ignore differences in perception is to ignore a major determinant of human behavior. Yet it is easy to assume unwarrantedly that everyone views the world from the same perspective as the viewer. (1964, p. 40)

As this implies, not only is lack of perceptual distortion, i.e., perceptual accuracy, a matter of interest, but also the distortion that arises from seeing others as similar to oneself, i.e., projection. In studies of what is variously termed person perception, social perception, person cognition, interpersonal perception, and social cognition, the phenomena of attributing to others one's own values is well recognized in psychology (cf., Tagiuri and Petrullo, 1958; Brown, 1965; Tagiuri, 1969). These studies are largely concerned with understanding the processes of interpersonal perception involved in the individual, and the projection phenomena is treated as a confounding effect. The early studies of Sears (1936) showed that individuals tend to project their own needs, often socially or personally unacceptable to themselves, onto others. Precker (1952a) showed that students, in a field study rather than a laboratory experiment, tend to attribute their own values (associated with education) onto associates--friends and faculty advisors--they chose. In another report of the same study Precker says that "We tend to attribute to objects of our choice those characteristics we ourselves possess and those valuings which are characteristic of ourselves" (1969b).

Precker's study shows that the person most preferred tends to be seen as having similar values. Smith (1957) showed this and also that the person not accepted is seen as having dissimilar values. He did this by having 28 students finish filling out two partially completed Allport-Vernon-Lindzey questionnaires supposedly from two other people. The students had previously filled out one in the usual manner to determine what their values were. One of the partially

completed forms given them was marked identically to their previously completed own one; the other in a converse manner to their own. The degree of similarity and dissimilarity was identical for all students. They also indicated which person they would prefer to associate with in a social and a task situation. The results provided support for the propositions that "1) The extent to which a person sees another as resembling himself in consequential aspects [in similarity of values] will determine at least to some degree the extent to which he will accept that person," and "2) The degree to which one person accepts another is related to the extent to which he projects his own values on to that person" (p. 260). Thus, the phenomena is not confined to simply those persons most accepted.

Hill (1967) argues that projection of one's own values arises, in part, because one's values define his own self-image. "Because values are internalized in a social context, the validity of these values--the validity of self-image--is assured only through support of the values within the same social context. . . . The identity and validity of self is reinforced in social interaction through mutual value support" (pp. 17-18). Later he presents the following discussion:

It would appear then that interpersonal friendship choice is based on both actual similarity of values, and projection of similarity. It would be expected that this projection would be a projection of ideal characteristics for the process of interpersonal attraction is based on value support, on bolstering the self-image. Greater support could be expected from attributing an ideal value to a friendship choice which one valued. Thompson and Nishimura (1950) support this hypothesis (p. 306): "Friendships may be determined, at least partly, by a compatibility of 'ideals' between two persons; and further, that each member of a pair of friends will regard the other as possessing those personality characteristics which he himself realizes, and be attracted to them for that reason."

Hill cites the following evidence, paraphrased in the following. Thompson and Nishimura had eight pairs of friends rate (1) his own personality, (2) his ideal personality, (3) his friend's personality and (4) the personality of a person who was not a close friend using a Q-sort of personality trait items. They substantiated their hypothesis. McKenna, Hoffstetter, and O'Conner (1956) further substantiated the hypothesis in a study of ninety college women with a Q-sort of statements for ideal self, actual self, and perception of first and second best friends. They found that perception of friends' personality was more similar to ideal self-concept than to the concept of actual self. From this and related

evidence Hill (1967, p. 32) postulated and found support for the proposition:

Proposition P2.3:\* An individual will tend to rate values he considers as central to his own self-image as desirable in others with whom he enters a direct relationship.

This proposition is directly tested in the present study with respect to 1) an "ideal" associate of the respondent, and 2) a group of actual associates. It would be expected that the rating (i.e., "projection") for "ideal" associate would be stronger than for actual associates.

Consistent with the various studies on liking, this phenomena is affected by the felt relationship between the perceiver and the perceived. Precker's study (1952b), previously cited, and others, show that the person most accepted tends to be seen as having the most similar values, and Smith's study (1957) indicated that the degree of acceptance varied with the degree of perceived similarity. Secord, Backman, and Eachus (1964) show that the tendency to assume similarity seems to be strengthened when the judge likes the person being rated on a personality assessment scale. In a detailed examination of the results of Jennings' (1950) study conducted in a training institution for delinquent girls, Homans (1961) was able to show that the more valuable were the activities for the group performed by one of its members, the greater the esteem in which this member was held. Marlowe and Gergen (1969, p. 627) note that, ". . . people do experience fewer disagreements with those who hold similar values and standards, find more to talk about with those who have similar interests and backgrounds, are more gratified when they find that another agrees with their world view, and respect others more who feel the same things are valuable that they do." (Under-score added.) These findings provide the proposition that:

Proposition P2.1: The higher the level of respect that an individual has for another person or group, the more he will tend to perceive the other as holding his own positive values.

The above two closely related propositions come from a literature that is concerned with interpersonal choice--who will choose whom as a friend, who will be best liked, etc. But what are the consequences in terms of behavior? Hill (1967) examines the effects of the science and interpersonal value structures of researchers on their work group structure--attraction to the group, cohesiveness, role differentiation, and sociometric pattern. He postulated that if group

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\* The numbering sequence from an earlier draft has been retained.

sociometric structure (pattern of interpersonal attractions) was based predominantly on actual similarity of values, then the smallest role differentiation (the extent to which the individual sees his role as being differentiated away from the group) would occur at the top of the structure, i.e., for those who were best liked. "The person in the group whose value-orientation most closely resembles the common group value-orientation would also tend to be accorded high friendship choice by the group, and so would be placed towards the top of the sociometric hierarchy " (pp. 4-5 of Hill's summary). On the other hand, if the basis of the group structure were predominantly projection, Hill postulated that the smallest role differentiation would coincide with the common group value-orientation more towards the middle of the group sociometric structure. He predicted and found that the latter condition obtained.

Discussing the consequences of projection in terms of group leadership as contrasted to perceptual accuracy on the part of the leader, Brown (1965, p. 640) observes:

The leader or popular person knows the group's views because they are his own; he is the modal person in the group. Then we may remember the proposition about popular leadership set forth by Riecken and Homans (1954) to the effect that a member of a group will be popular in the degree that he realizes the norms and values of the group. Or we may think of the closely related idea in balance theory (e.g., Heider, 1958) that people are attracted to those who are similar to themselves. The person having the greatest aggregate similarity to others will have the greatest aggregate popularity and will be the best (projective) judge in this group.

Projection, then, may supplant actual similarity of values as a basis for experiencing few communication problems with another group. While there does not appear to be any more direct support in the literature for relating this perceived similarity to communication than for actual similarity, the literature does indicate a similar relationship between perceived similarity and liking as for actual similarity and liking. Reasoning as before provides the proposition:

The more an individual perceives another as holding his own (positive) values, the fewer the communication problems he will tend to perceive.

However, projection may provide an inadequate basis for relationship under some conditions. In particular, when there is a large disparity in actual similarity, but one perceives the other as being similar, adverse effects may result. Given that one's conception of another group with which he had a task relationship were quite incorrect, he would likely make his task decisions affecting them



and address messages to them that they would evaluate quite differently than he anticipated. The ensuing problems in communication would arise in a manner similar to that in Pl.2. The proposition is then:

Proposition P2.2: A. The more an individual perceives another as holding his own (positive) values, the fewer the communication problems he will tend to perceive, but, B. the less the actual similarity, the more perceived communication problems will tend to increase with increasing perception of similarity of values.

### 3.7.2 - Perceptual Accuracy

Projection is one of the factors that affects one's ability to perceive other's needs, valuings and beliefs. Closely related is the consequent discrepancy between what one believes another's values are and the actual values of the other; i.e., perceptual accuracy. Again, Leavitt (1964) succinctly establishes the practical importance of perceptual accuracy:

For managerial purposes, the importance of the perceptual world is clear. If one's concern as a supervisor or counselor or committee member is to try to effect some change in the behavior of other people, and if in turn people's present behavior is determined largely by their perceptions of their environments, then it is critical that one seek to understand their perceptions if one is to understand the circumstances under which their behavior might change. (p. 35)

Brown (1965, pp. 637-8) states that, "Accurate perception of persons is supposed to be important because it permits prediction of behavior which is essential for smooth interaction [i.e., communication] ." Further, he observes that:

It is often said that accuracy of person perception in everyday life must be high since social interaction ordinarily works smoothly. Certainly we need to have and do have great accuracy in foreseeing what people will do when we interact with them, but much of this foresight is at the level of roles rather than personalities. A knowledge of social structure alone will take one smoothly through a large part of the day's routine. (p. 637)

In part, this is the basis for the prediction that actual similarity of values is not important in communication at low levels of task interdependence. When one goes to a person in another group on rare occasions to obtain some advice, the advice is usually forthcoming. However, if one goes with a request to utilize a group's environmental test chamber for a week, or to seek some other relatively costly favor, accuracy in perceiving the bases upon which they will evaluate what is said and the request, could make a significant difference in the response. Such a situation goes beyond the usual social norm of helpfulness and expected role behavior.

Mellinger (1956) in his study of liking and trust in a group of researchers, found that subjects who have communicated to others about a specific issue were more accurate in their assessment of the values held by others than those who had not communicated. Newcomb (1956, p. 478) asserts that, "Attraction toward a co-communicator varies with perceived similarities of attitudes towards the object of communication." Triandis (1960, p. 175) suggests that the accuracy of perception of attributes used by others in evaluation and discourse may increase the amount of communication between a pair. Pound (1966), utilizing this literature, as well as other items pertaining to the perceived relevance of new project ideas, derived the following proposition: "The greater the accuracy of perception of one individual in a laboratory by another, the greater will be the frequency of idea communication from the second to the first." Unfortunately, he was not able to test the proposition adequately because of difficulties in measuring the frequency of such communications. (They were found to occur quite sporadically which made it difficult to sample the communications adequately in a manner practical for both the participants and the researcher.)

However, it appears that the concept of "perceptual accuracy" is quite complex apart from questions involving the psychological process by which it works, if indeed it even exists. The problem involved is indicated by the title of Cline and Richards' (1960) article: "Accuracy of Interpersonal Perception - A General Trait?" Is accuracy a general trait or does it depend upon whom we are perceiving, under what circumstances, and upon what sort of judgements we are making? The literature appears to be equivocal. The methodological complexities were clarified in the mid-50's by Cronbach (1955, 1958), Gage and Cronbach (1955) and Brofenbrenner, Harding, and Gallwey (1958). Studies by Gage and Cronbach (1955) and others (cited in Cline and Richards; also see Tagiuri and Petrullo, 1958; Brown, 1965; and Tagiuri, 1969 for reviews) suggested that perceptual accuracy was not a general trait because "there was little relationship between accuracy of perception scores derived from two or more different instruments or procedures" (Cline and Richards, 1960, p. 1).

In Cline and Richards' study, which was developed through a series of experiments, the participants viewed color films of ten interviews with a cross section of people varying in age, sex, educational background, and social status. Extensive measures were taken to obtain accurate data about the individuals. This was used as the standard against which the participants responses to a variety of questions were compared. They conclude that "The results of this study . . . indicate that there is a general ability to perceive others accurately. This

general ability, however, consists of two (at least) independent parts: Sensitivity to the Generalized Other and Interpersonal Sensitivity in Brofenbrenner's terminology, or Stereotype Accuracy and Differential Accuracy in Cronbach's terminology" (p. 5). (These studies are further described in Cline (1964).) They go on to note that this complexity does not negate the utility of the concept since such complexity also holds for other commonly used concepts such as "intelligence." The practical utility to be derived from the concept is appealing, as indicated in the earlier quotations from Leavitt and Brown, and in the proposition suggested in section 3.6 for the selection of coupling agents. Fiedler's "Least Preferred Co-worker" instrument that he has used in his leadership studies (cf. Fiedler, 1967) is closely allied to the question of perceptual accuracy; so it, too, with all the practical aspects involved in terms of organizational design, is apparently subject to similar methodological and theoretical problems.

It appears that any investigation heavily dependent upon "perceptual accuracy" would be a major project. Hatch (1962) sought to determine the "empathy"--another term applied to perceptual accuracy--of a group of 30 branch managers of Minnesota Mining and Manufacturing Co. He obtained data from 318 of their subordinates and using an elaborate and complex data processing procedure, he developed a questionnaire tailored to each manager that eliminated all known sources of bias and methodological artifacts. Judgments about the managers on several factors were obtained from several sources. The final results indicated that empathy, as he measured it, was not related to "human relations skills," but was somewhat related to degree of acquaintance between the managers and their subordinates and a measure of the managers' confidence in their questionnaire responses. As a group his good judges of subordinates' responses were able to predict at better than chance ( $p < .05$ ). Hatch notes that much of the prediction of the study could be accounted for by chance alone.

We have included one proposition involving perceptual accuracy for three reasons: 1) If it is supported, it would then merit further investigation in a more suitably designed study--but it could not be accepted on the basis of this study. 2) The design of the instrumentation for testing Propositions P2.1 - P2.3 requires several of the methodological requirements for the following proposition to be met. 3) There is no additional "cost" to the respondents to provide the requisite data. The proposition is:

Proposition P2.4: The greater the discrepancy between the work-related values imputed to B by A and B's self-reported (i.e., "actual") values, the greater the perceived communication problems with B.

In addition to treating work groups as subjects in this study-- discussed more fully in section 3.9--they were also treated as objects of perception. The respondents were asked to rank order a set of items (in questionnaire CD Q09) as they thought the other group would (see section 4.5.4). They were not asked to perform this task for individuals. The methodological work of Cronbach (1955, 1958) and others cited previously, has shown that even when judges are supposedly responding to individuals, one component of their score is due to the way the judges categorize the individuals as members of a more general group or stereotype. "Impressions of a subgroup may, of course, be founded on person perception but it is a kind of person perception that is distinguishable from the perception of differences among individuals in a subgroup" (Brown, 1965, p. 641). As noted in the quote from Cline and Richards (1960), in their experimental studies of individual person perception, "sensitivity to the generalized other" and "interpersonal sensitivity" with respect to individuals appear to be independent components. The work of Broffenbrenner, et al (1958), and the analytical work of Cronbach also supports this point.

Two other components that arise in the typical scoring methods for judging similarity are "elevation" and "differential elevation" (Cronbach, 1955). The first is associated with the mean level of response that a judge may have in his responses to multiple choice format questions, and the second is associated with the variance in these responses. In this study, a rank order instrument was used, following the implied suggestion of Cline (1964, p. 270), which eliminates these two components.

### 3.8 - SUMMARY OF PROPOSITIONS

The following propositions were tested in this study, except the first:

- P1.1: For a given level of task interdependence perceived by an individual between himself and another person, the less the similarity of his work-related values to those of the other, the greater the communication problems he will perceive as existing between them.
- P1.2: For a given level of task interdependence perceived by an individual between his working group and another group, the less the similarity of his work-related values to those of the other group, the greater the communication problems he will perceive as existing between the two groups.
- P1.3: For a given level of task interdependence perceived to exist between two working groups by the members of those groups, the less the similarity of the work-related values of the two groups, the greater the communication problems each will perceive as existing between the two groups.
- P1.4: For groups with a high level of homogeneity in their work-related values, perceived communication problems with other groups will tend to be much better or much worse than for groups with a moderate degree of homogeneity in their work-related values.
- P1.5: For groups with a low level of homogeneity in their work-related values, perceived communication problems with other groups will tend to be worse than for groups with a moderate degree of homogeneity in their work-related values.
- P2.1: The higher the level of respect that an individual has for another person or group, the more he will tend to perceive the other as holding his own positive values.
- P2.2: A. The more an individual perceives another as holding his own (positive) values, the fewer the communication problems he will tend to perceive, but  
B. the less the actual similarity, the more perceived communication problems will tend to increase with increasing perception of similarity of values.
- P2.3: An individual will tend to rate values he considers as central to his own self-image as desirable in others with whom he enters a direct relationship.
- P2.4: The greater the discrepancy between the work-related values imputed to B by A and B's self-reported (i.e., "actual") values, the greater the perceived communication problems with B.

In addition, the following propositions were formulated:

The greater the disparity in work-related values between functionally dependent work groups, the more contacts between the groups will tend to be restricted to a limited number of people and/or in frequency of contact, at a given level of functional dependence.

Individuals whose values are intermediate between two groups will be regarded as effective communicators with either group.

Individuals whose perceptual accuracy for another group's values is high will be regarded as effective communicators with that group.

The discussion in conjunction with Proposition P2.4 indicates that the last proposition above, involving "perceptual accuracy" would require a very extensive study and would not likely provide results of practical utility.

### 3.9 - GROUPS AS A UNIT OF ANALYSIS

A final comment should be made on the units of analysis in this study. They are the individual, the group, and the group pair. The individual is frequently used in many studies as the basic unit of analysis. He is clearly recognizable and easily identified. For propositions involving the relationship between two groups, the pair is the appropriate unit of analysis and can be readily treated once the groups are identified. The difficulty arises in defining and identifying the group.

In this study, R&D groups were taken as administrative units. The members of each "group" were specified by higher level administrators in each organization. However, the question of "What is a group?" is not easily answered. Like many familiar terms, we think that we understand it clearly until we attempt to give it an operational definition. When attempting to define the term as a part of a rigorous investigation, the answer is not simple, and is not often attempted. Most writers implicitly take the approach that March and Simon do in "defining" organization: "It is easier, and probably more useful, to give examples of formal organizations than to define the term," (1958, p. 1).

In some studies the formal organization structure and the groups contained in it are taken as given. As a part of the Ohio State Leadership Studies, Scott (1956) determined the perceptual errors of enlisted men in describing the formal organization structure in one phase of his study, but were the "errors" indeed deviations from reality? The question was not raised in the report of the study. Studies based on interview or questionnaire data commonly accept the formal definition of organizational units. Studies based on observation, most of which have been concerned with the blue collar worker, define groups in terms of the verbal, non-verbal and mechanical interactions among the members (e.g.,

the classic study of Roethlisberger and Dickson, 1943). Homans states that: "A group is defined by the interactions of its members," (1950, p. 84). In this context, interaction refers to "participating together in social events." He notes that people may belong to more than one group and that the definition is relative: "The meaning depends on what persons and groups one chooses to consider outsiders to the group in question," (p. 85). In other words, it depends upon the purposes of the observer.

Weiss (1956) in his analysis of data collected by Jacobsen and Seashore (1951) found that where the organization chart indicated three organizational levels, sociometric measures based on the frequency of communication between individuals revealed only two levels (1956, p. 56).

Campbell (1958) has considered the problem of defining social entities, of which groups are one form, in terms of coefficients for common fate, similarity, proximity, resistance to intrusion, internal diffusion, transfer, and communication. A major point of his discussion is that:

It might well be alleged that any scientifically useful boundary must be confirmable by at least two independent means. Such an emphasis seems necessary if sociology is to retain those attitudes of discovery, problem solving, independent confirmation and validation of construct which have characterized the successful sciences. (p. 23)

His discussion makes it evident that there is no simple solution to the problem. In the second phase of his study, Scott (1956) sought to study mutual perceptions of submarine crews pertaining to status relationships and performance. He notes that "Smith (1945) has defined a social group as an aggregate of individuals who have 'collective perception of their unity' and who act 'in a unitary manner toward the environment'," (p. 63). This definition suggests several possible ways of operationalizing the definition of a group by examining the mutual perceptions of its members, and is related to the basis of a number of sociometric measures used in group measurement (Moreno, 1953).

As suggested in section 3.2.5, Group Boundary Relations, one of the ways that two groups may be coupled is for some personnel, originally members of one group, to essentially become "members" of the other group, at least for a period of time. This frequently occurs in many R&D organizations where individuals may have a base in one group and work in other groups on various projects. This type of multiple group membership can be defined in terms of the interactions on

a specific task. Physical proximity, in addition to interaction patterns, also provides a basis for defining a group. Project related activity would be expected to lead to a high rate of communication among members of the group relative to other members of the larger organization.

In the R&D context, the "common fate" index suggested by Campbell could be related to the individual's involvement in determining the outcome of a project. This would probably be particularly applicable to determine the core group managing a project in a large organization. Physical proximity would be most unlikely to identify such a group and frequency of contact would not necessarily serve to identify them.

Groups may also be identified in terms of similarity in any of a number of features. Similarity of values is one such aspect, but while this may be a useful method for identifying spontaneous or natural groups, it would not necessarily serve to identify groups in an organization where individuals are assigned, at least to some extent, to their groups. Depending upon the nature of the propositions, in some studies it might be useful to define groups in terms of value similarity. However, this cannot be done in this study since some of the propositions involve the effect of similarity in values on communication.

In this study we had managers identify groups of people that worked together on given types of tasks. The people in these groups were parts of administrative units. They had a common fate, in part, in that in most cases they had a common supervisor who would have some effect upon their day-to-day activities and rewards over relatively long periods.

The group members may also have perceived themselves to be sharing a common fate with respect to the tasks or projects they work on, at least with respect to the information and decisions they provide to or receive from the group with which they are paired for the study. Many other potential measures can be developed from Campbell's seven categories: common fate, similarity, proximity, resistance to intrusion, internal diffusion, transfer, and communication. Several indicators of group membership obtained in this study are presented in section 4.5.6.



## Chapter 4

### FIELD RESEARCH DESIGN AND INSTRUMENTATION

#### 4.1 - RESEARCH DESIGN

##### 4.1.1 - Selection of Method

There are a variety of methods in the research processes of the social sciences. Most disciplines characteristically use particular methods--the experimental psychologist typically uses rats in tightly controlled laboratory apparatus, the anthropologist observes a tribe while living with them, the sociologist interviews people in a community and gives them questionnaires--to name a few examples. Each technique has its strengths and weaknesses in terms of the insights it provides the researcher, the adequacy with which he can test his concepts, and the effects of uncontrolled or unaccounted for influences on his process.

In the field of organization theory, Rubenstein (1963a) distinguishes a number of research methodologies as listed in Figure 4.1-1. The propositions of this study could potentially be tested by several of these methods--small group experimentation, field study, field experiment, survey research, or case study. The case study is useful for giving "outsiders" an understanding of the complexities of particular situations and for generating tentative hypotheses about a process. Its ability to suggest many propositions is both its strength and weakness. Various readers may arrive at different conclusions and the insights obtained are strongly dependent upon the training, skill, perceptiveness, and other such personal characteristics of the case writer. That which is abstracted out of the situation leaves many rival hypotheses unaccounted for (Douds, 1969). Small group experimentation in the university laboratory provides the opportunity to control many effects that may jeopardize the findings of an experiment, (Campbell and Stanley, 1966). However, it is more difficult to create the main effects sought, in part, because the laboratory sessions are only a small part of the participants' activities and concerns--they typically meet for short sessions a few times. In this particular study, "mature" groups are sought whose interaction patterns within and between groups have stabilized to the point where all the participants have had a reasonable opportunity to learn something of how the others think and how they behave in communicating with each other.

Small group experimentation  
Mathematical modeling  
Simulation  
Field studies  
Field experimentation  
Survey research  
Case study  
Proposition formation  
Speculative theorizing

Figure 4.1-1 - Some Distinguishable Methodologies in the Study of Organizational Behavior

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Survey research involves collecting data from a large number of people; typically through a mailed out questionnaire or a single, usually brief, structured interview (Campbell and Katona, 1953). The survey technique is perhaps most applicable to sets of variables where information about both the dependent and independent variable can be provided from the same source, independently of information provided by other people about the same events or situations. Frequently the survey technique is used in connection with studies of attitudes.

A field study typically involves a more intensive investigation of a smaller population or sample. In fields such as organization theory or industrial psychology, the study may be limited to one or a few organizations. This provides the opportunity to investigate research questions in much greater depth.

Rubenstein and Haberstroh (1966, p. 689) state:

The field study method permits flexibility of research design and the opportunity to modify data-collection methods and the nature of the specific data required as the study progresses. This permits the researcher to capitalize on what he is learning about the organization. This is a critical part of the field researcher's strategy, but does not eliminate the possibility of a rigorous field study design. The overall design can be constructed in advance of actual entry into the field site, but it must be subject to modification if the advantage cited above is to be achieved.

It is better to have a smaller amount of good data, than a large quantity of poor quality data. And it is better to have some indication of significant rival hypotheses or confounding effects than no knowledge of them whatsoever. It is difficult, if not impossible, to provide such flexibility in the large-scale survey. Changes made during the course of this study will be indicated at appropriate points in the discussion.

The survey and field study techniques may be combined in the investigation of a topic. The advantage of the field study is that it allows the variables of some propositions to be investigated in depth and a number of rival propositions to be explored or discovered, but it is typically restricted in the number of sites or situations covered. The survey has the advantage of covering a broader range of sites or situations, but typically in less depth. Combination of the two techniques is illustrated in the study conducted by Kahn, et al (1964), on the sources of stress for individuals in organizations. A major part of their book is based on a field study involving intensive interviews with selected people in organizations and those with whom they interact. Another part of the analysis was based on a nationwide survey of individuals. This part used a smaller number of variables. Among those omitted were variables based on the responses from a pair of people--the focal person and one of those with whom he dealt. The dividing line between field study and survey techniques is not a sharp one. A survey that is limited in the number of organizations it covers may include data collection by methods other than questionnaire. A field study may include a number of sites and make extensive use of questionnaires. In order to determine the flexibility and controls for rival hypotheses the design features of a given study have to be examined: they are not inherent in the designation of the technique.

Field experiments (or more strictly, quasi-experiments, as the term is used by Campbell and Stanley, 1966) can provide much better opportunities to control for the wide variety of effects that may produce spurious support or obscure valid support. However, the practical problems of setting up field experiments are considerable for the external researcher, i.e., one who is not a part of the decision-making process in an organization. Within organizations, many opportunities for such experiments exist and could be used to good advantage by the organization. Sometimes similar opportunities for "quasi-experimental" studies can be discovered by the researcher when adequate data records exist, as illustrated by Campbell (1969). Two field experiment designs that could be

used in an extension of this study are outlined at the end of this section.

The field study method was used in this research. The case method does not allow most types of propositions to be tested. Some of the propositions here could be tested in the small group laboratory, but this would leave their relevance in the operating organization undetermined. The nature of the variables in several of the propositions requires information about the same phenomena to be obtained concurrently from individuals in a pair of groups, thus making the typical survey approach infeasible. By using the field study method, we were able to investigate working groups that had already been formed. Life in the groups was a reasonably important part of the total life of group members. The groups were mature in the sense that their internal relations were reasonably stable, and similarly, their patterns of interaction with other groups had stabilized.

#### 4.1.2 - Design Components

The basic mode of operation of a field study may be developed and described in terms of a number of "design components" (Moor, 1969). These components include:

1. Desired basic data sources
2. Data collection instrumentation
3. Selection of organizations and respondents
4. Activity sequences and time durations
5. Data reduction and analysis

The relationships among these items, as in any design problem, are complex, interdependent, and not sequential. Each item imposes constraints upon the other and each must contribute to the objectives of the project as a whole. Design criteria related to the propositions are given below; criteria related to other considerations are discussed in Section 4.2 under selection of field sites.

The over-all objective of the design is the acquisition of communicable knowledge. In particular, the objective is to prove the ideas and propositions expressed in Chapters 2 and 3. Basic criteria for this objective are: to what extent are my results believed by myself, my advisor, my committee, my colleagues, my professional peers, and R&D managers; what have I learned about the research process; and what new ideas have I formed. These criteria are operationalized by a number of post hoc measures such as: the conferring of a degree, acceptance of an article for publication, and the changes in design and execution of the next research project. A priori criteria may be derived from these to evaluate the design features. Their general form is well described in texts.

(e.g., Festinger and Katz, 1953; Adams and Preiss, 1960; Selltitz, et al, 1965; Kerlinger, 1965; Campbell and Stanley, 1966), and appear here in various sections, sub-sections, and sentences concerned with acquiring data that actually measures something of specific use, the relation of what is measured to intentions, and the accountability of what is not included in the data base.

The basic sources of data (item #1 above) in this study are individuals: a) individuals with a scientific or technical background who are members of working groups in R&D organizations, and b) managers who are knowledgeable about the group. Groups primarily involved in carrying out the technical tasks of the organization and who had an opportunity for the coupling of new technical ideas were desired. The groups were selected in pairs that had some degree of task interdependence upon each other. The number of individual respondents required would necessarily be relatively large since some of the propositions involve pairs of groups. Prior experience indicated that a working group is typically formed of three to five people. A study of only 10 group pairs would involve about 80 people. This study involved 72 pairs and over 280 people.

The data collection instrumentation is in the form of questionnaires, interviews, and Q-sorts. These instruments are described in detail in later sections of this chapter. The instrumentation selection was constrained by the relatively large number of respondents involved, the diverse geographical location of the participating organizations, and the time constraints on the investigator.

Both industrial and government organizations were invited to participate in the study. While the values of engineers and scientists in industrial organizations may be different from those in government organizations, the propositions of this study do not involve their values, per se. Rather, they involve the differences in values and perceptions of people who deal with each other, so various types of organizations could be used. It was recognized that it would be of great interest to test the propositions on an inter-organizational basis; that is, where one group of a pair is in one organization and the second in another organization and there is at least a moderate degree of task interdependence. However, it was anticipated that the practical problems involved in gaining entrance to a sufficient number of organizations for this type of study would not make it feasible for dissertation research. Discussions with key personnel in three government agencies indicated that it would be feasible to request the participation of four to eight groups in each organization contacted.

The field site entré and respondent selection process is described in greater detail in Section 4.2.

The activity sequence in each field site began with one or more contacts initially made to gain the participation of the organization and to select the groups. Data collection activities then followed. However, as described in the next section, this study is one half of a project including the study by Richard Barth, using the same sites and respondents as data sources. Data collection for his study required one session for filling out questionnaires and interviews. This study required the same, plus completing a final 15-minute questionnaire at a later time. The procedures for handling these activities are described in Section 4.3. Data reduction and analysis procedures are described in Chapters 5, 6, and 7.

#### 4.1.3 - Methodological Considerations

In field studies there is inherently a lack of control over a wide variety of largely unknown potential influences. These uncontrolled variables throw doubt on any findings that the relationship between variables is due to the reasons hypothesized. The process of arriving at credible support for even a "little theory" requires many cycles of investigation, experiment, and analysis. Given an insight, however arrived at, the researcher puts it into a form in which it can be tested and then seeks some empirical support. Finding this support he may then go on to derive some further implication of his theory and then repeat the process. The cumulative effect of many such extentions establishing links from one variable to another, from one part of the theory to another, is to establish the functional unity (Peak, 1953) and credibility of the whole.

Initial investigations in a study may produce some statistically significant results. Some statistically significant results are likely to appear as random events if a large number of variables are involved, or the variables "are close to the data." By the latter we mean that the variables and the indicators are essentially the same. This would be an illustration of "definitional operationism" (Campbell, 1969a). Only replications of such studies will show if the same relationships remain significant and were not chance events initially. On the other hand, relations may be found in such exploratory work that lead to new insights, new potentially valid theories, and new paths to follow. More often in the research process, the findings are equivocal, either initially or upon

later investigation. This may occur because of the variety of threats to the internal or external validity of the findings describing the relationship among variables as described by Campbell and Stanley (1966).

But statistical significance, alone, does not necessarily indicate that the "truth" has been discovered. The possible distortion in the results of the analysis arising from assumptions about the nature of the scales and the sampling distribution are but one of many threats to the validity of research findings. The presumption seems to have gradually evolved among many in the social sciences--judging by the nature, style, and implications of the tone in many publications--that the statistical test of significance provides proof of the relationship tested. Winch and Campbell (1969) note ...

the following three basic errors in the use of tests of significance:

1. The interpretation of the significant outcome of a test as proof of a given interpretation of the relationship.
2. Equating statistical significance with substantive significance. . . .
3. The use of the wrong error term in "dredging" operations and other multiple comparisons. . . . Such procedures often involve hundreds of comparisons and employ error terms that are far too lenient with respect to Type I error.\*

They point out that such statistical tests only involve one threat to the validity of findings, only one out of fifteen threats they identify. (These threats are treated in greater detail in Campbell and Stanley, 1966.) "Even though we believe the significance test is of critical importance in weighing the plausibility that a relationship exists, we advocate its use in a perspective that demotes it to a relatively minor role in the valid interpretation of sociological comparisons," (Winch and Campbell, 1969).

An important goal of scientific activity is to develop theories with great explanatory power. Newton's theory of gravitation is clearly such a case, explaining a wide range of phenomena. The power of a theory is dependent upon the postulated relationship among the variables--as conventionally emphasized--and upon the nature of the variables themselves. It would appear that the current

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\* A Type I error is rejecting the null hypothesis when it should not be rejected. This implies the error of accepting a statement as true when it is not.

reward system of social science emphasizes the development and testing of propositions and theories moreso than a critical examination of the variables from which they are constructed, (cf. Campbell, 1969b, p. 366). Eventually, initially promising findings may be found to be the results of artifacts--initially unaccounted for threats to the validity of the relationships "discovered." Campbell, in his discussion of methods to control artifacts in behavioral research, makes the following observation, with particular reference to building construct validation controls into dissertation studies (1969b, p. 367):

If we are indeed in an extremely difficult arena, then there is even a motivational utility in the regular occurrence of exciting findings which later are discounted as artifacts. These provide exciting rewards to the would-be discoverers, and exciting rewards to the successful critics (the more exciting the greater the reputation of the false claims). These are rewards and motivation for experimental work and empirical exploration. Both would be lost under a procedure that effectively screened out overoptimistic pseudo-confirmation of exciting theories.\*

Equivocal results may arise because of the internal and external threats to the validity to the nature of the relationships postulated; they may also arise because of the nature of the variables themselves. Many of the discussions in standard texts on research methodology and behavioral measurement (e.g., Festinger and Katz, 1953; Selltitz, et al, 1959; McNemar, 1962; Kerlinger, 1965) focus attention primarily on the reliability and validity of the measurements of the variables. These considerations are vitally important and will be briefly considered in the next chapter. The validity issue is particularly difficult. In part, it deals with the question: How well do given sets of measurements measure what they are intended to measure? This problem is dealt with by using different techniques or sources of information to measure the same variable (convergent validation). Another aspect of the validity issue concerns the distinction between a given concept and others from which it should theoretically differ (discriminant validation). At the measurement level, a technique is now available to operationally investigate the validity of constructs--the variables themselves that enter into the theory--without having to extensively test the theory itself. This is the multitrait-multimethod matrix for convergent and discriminant validation developed by Campbell and Fiske (1959). It is described and utilized in Chapter 5.

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\* From citations of Campbell given, and to follow, the reader will recognize that this statement is contrary to his continuing interest in better methodology.



#### 4.1.4 - Potential Natural Experiments

The essence of planned experimentation includes a deliberately induced change, the "experimental treatment." A "natural" experiment takes advantage of a change occurring in the field situation, a change that is not deliberately induced by the researcher. There are types of changes related to the independent or dependent variables that can be anticipated beforehand as likely to occur. In a cross-sectional study, such changes, unrecognized, merely serve to obscure the postulated relationships, and so constitute threats to validity. Identified beforehand, recognized during the study should they occur, and pursued to the point of collecting data, they serve to increase the validity of the findings, more clearly refute them, or potentially serve as the nucleus of new propositions. Of course, by "removing cases" from the main body of the data, and by being singular--or at best being a limited number of cases in a particular quasi-experimental design--statistical reliability and validity are not necessarily enhanced. But opportunistic natural experiments can be beneficial and worth following. The following discussion will briefly outline several possibilities that were identified before the field data collection began.

1. Change in group membership. If a new member enters a group being observed, some shift in the values of the group can be expected to occur. Depending upon a variety of characteristics of the individual and the group--which we shall not enumerate here--culminating in an observable shift in values and the task assignments of the individual--changes in the communication relations with the other group could be expected to occur congruent with the propositions of this study.

2. Change in group leader. Presumably the group leader has a significant effect upon the group and the manner in which it performs its work. The effect of a change in group leader might manifest itself in a change in the values of the group (although we would postulate that it would take some time for such a shift to occur in most cases). The propositions of the study would then indicate that a shift in the communication relations would occur. It is also possible that the new leader would change the implicit or explicit "rules" about communicating with other groups. This would lead to case #13 below.

3. Change in group membership involving groups A and B. An especially interesting sub-case of case #1 would occur if one member of an observed group pair would be transferred to the other group, or a two-way swap would occur, either on a temporary or permanent basis. Presuming the focal person(s) were to continue to be involved in the activities that constitute the basis for the interdependence between the groups, the change in values towards greater congruence and improved communications would normally be expected in line with our propositions. However, this involves the dynamics of the processes taking place within the groups--which are not the subject of this study--and so other outcomes might be predicted by a more comprehensive theory involving variables not necessarily measured here.

4. Change in "liaison man." An opportunity to directly test propositions involving coupling agents is provided if 1) one person carries on much of the dialog with another group and this person is changed, 2) such a position is created, or 3) other similar changes occur involving more than one position.

5. Change in basis of performance measurement. A leader or higher level manager may change the basis of measuring the performance of individuals or groups. Under some circumstances this would lead to a shift in task-related values. Such shifts should result in a change in communication behavior predicted by the present propositions. Expansion would be required to predict what the changes in the value structures would be.

6. Change in rewards. This is similar to the above. The point of interest for this study is, given an announced change: Do changes in values occur and do corresponding changes in communication behavior (and task performance) take place? While performance measurement and reward structure are often discussed in terms of motivation, here we would explore their effects in terms of "state" variables--the values--and their relation to communication and the conduct of the work.

7. Clarification of ambiguity or uncertainty about evaluative bases. For a variety of reasons and through a variety of means, the specific bases for evaluation relevant to the work being performed may be clarified or made more specific. Of particular interest here are the situations where there is a reduction in the discrepancy between groups (between what A attributes to B and what B ascribes to themselves), or the discrepancy group members have as to what their own group's values are.

8. Change in task. Completion of one task and the start of another, the introduction of an additional task, or the ending of another task, where all are common to the observed group pair, can change the task inter-dependence between the groups. Also, the addition or ending of a task in one group, but not the other, can change the level of task inter-dependence. This provides the opportunity to test the effect of this variable on the propositions.

9. Change in task distribution. While the project may remain essentially the same, technical or organizational changes may be made resulting in a restructuring of the project task content and responsibilities. These may interact with the evaluative predispositions or cause changes in the level of interdependence.

10. Change in time deadlines. Changes in the time when work output is due can cause changes in the level of interdependence and the communication rate between the groups. Our propositions would indicate that increased interdependence would lead to an increased rate of communication. Whether the difficulties in the communication process would then increase or decrease is predicted. But whether an increased time pressure would lead to an increased level of interdependence has not been indicated. We postulate that it would change and the change would be a curvilinear function of the difference in task-related value structures between the groups.

11. Change in proximity. If the physical location of the groups were changed so as to tend to bring them into more frequent or less frequent contact with each other it is possible that there would be some shift in their evaluative bases and the difficulties in communication. Assuming that the level of task interdependence remains the same before and after the change and that the

change in distance between the groups is "large," bringing them into close proximity, we would anticipate some change in the evaluative bases of both resulting from the change in frequency of contact. Such predictions could be elaborated. In general, they would probably tend to be rather weak, being dominated by other factors in the work environment. However, in some organizations there are frequent opportunities to test the effects of changing the locations of desks.

12. Changes in other physical aspects and information services. Certain items when linked to particular requirements of a given situation due to the nature of the work, the phase of the work, or the way it is customarily done--such as providing unrestricted and immediate access Xerox service, conference phones, additional clerical help, etc.--may make a crucial difference in the ability to communicate needed information. This may ameliorate communication difficulties directly and thereby changing the base line reference level for the propositions under test.

13. Change in meetings - number, membership, agenda. Some characteristics of formal meetings are quite readily manipulated. Non-formal meetings are more difficult to deliberately control, although subject to influence by the explicit or implicit rules a group leader may establish over the flow of written communications, release of documents, and who should talk to whom about what. These may lead to changes in some values although these would probably be less strong than the direct effects upon the communication process itself and the consequent changes in communication difficulties. Of particular interest would be a change leading to the reduction in the interaction between two groups with a major difference in their evaluative structures and an average-to-large discrepancy in their views of what the other group's values are. For there to be a reduction in the communication difficulties it might also be necessary for there to be a liaison agent intermediate in evaluative structure or with a low perceptual discrepancy as to the other group's values.

14. Change in written reports or reporting. Such changes may be a direct response to communication difficulties--real or imagined (i.e., "on target" or "off target"). Again, this represents a common organizational "solution" to various problems. It would be of particular interest to trace the connection between the evaluative predispositions of those involved, the substantive nature of the issues involved, and the resulting changes in information exchange behavior. This is moving to a more detailed level of analysis than is proposed for the present study and to "process" propositions not included in the present set of "state" propositions. It would be exploratory for the next major stage of research.

15. Change in the "organization chart." The relation between the organization chart and organizational behavior is both complex and ambiguous. Essentially the same comments as in case #14 apply here.

#### 4.1.5 - Two Design Extensions

The field study design described in this chapter is of a cross-sectional nature with part of the data gathered in any given group at two points in time and other parts at essentially one point in time only. If evidence is adduced from this study indicating some validation and/or modification of the propositions, then it would be of interest to extend the research, particularly with regard to obtaining a better understanding of the dynamics involved in the coupling process.

Two designs are suggested here that would provide a follow-on to the present study. The first is a field quasi-experiment (Campbell and Stanley, 1966) utilizing naturally occurring communications events in a "real time" study. The second, while initially appearing to be a simple variant of the first, is actually a field experiment in which changes are intended to be induced in the behavior of the participants. It tests the proposition that making people more aware of each other's value systems will cause changes in their communication and decision making behavior.

Longitudinal, Real-Time Study of Communication. This would be done for the purpose of determining how reported communication relationships measured by instruments used in the study reported here compare with "actual" communication experiences over a period of time, and locating quasi-experimental opportunities. This design is a Campbell type 8: Equivalent Time Sample Quasi-experiment (Campbell and Stanley, 1966). The experimental treatment "X" is the naturally occurring communication incidents between groups. The observations are data collected on particular incidents, say once a week, by the researcher. The data collected pertains to the information exchange, communication behaviors, and reactions thereto.

$G_{ij}:$        $O_{vc}$        $XO_c$        $XO_c$        $XO_c$        $XO_c$        $O_{vc}$

Data is collected from pairs of groups,  $G_{ij}$ , beginning with the complete set of instruments,  $O_{vc}$ . Observations are then made using information exchange, communication instruments only,  $O_c$ . Ideally, observations are collected from each group in random order. After the incident is named and data collected from one, the other group is then immediately contacted to obtain data about the same incident. If observations are made once a week, this provides for analysis,  $N =$  (number of group pairs)  $\times$  (number of weeks). The  $O_c$  data is probably amenable to

remote collection. The complete set of instruments would be given again at the end of the experimental period. Note that this design does not directly collect data on values during the real-time, remote data collection period.

Longitudinal, Real-Time Study of Evaluative Bases and Communication. This design is stimulated by the desire to add real-time data on values and decisions to the first design. However, when this is done the nature of the experiment changes drastically--the observations become experimental treatments. This happens because it is reasonable to expect that repeatedly asking people about the bases of evaluation in a number of incidents will make them more aware of them than they normally are and they may then begin to more explicitly take them into account in future interactions with other groups.

The research question becomes: Does making people more aware of their task-related values and those with whom they deal affect their communication behavior? The hypothesis is: Increasing individuals' awareness of their own and other's values in the context of specific situations will affect their communication behavior--reducing the problems in communication (hopefully, in most situations), but under some conditions increasing the problems (probably by making manifest the latent conflict over differences in values).

The design is basically Campbell's type 10: Nonequivalent Control Group Design represented by:

$$- \frac{O}{0} - \frac{X}{-} - \frac{O}{0} -$$

The control group treatment could be as diagrammed; that is, no data is collected from them between the initial and final administrations of the O instruments. However, the X here consists of a series of observations about communication incidents, as above, but with the addition of data collection about the bases for evaluation evidenced in each communication-decision incident. These are represented below as  $O_{Xvc}$ . The associated incidents--which are not experimental treatments for this group--are represented by x. For the control group, the incidents are considered as treatments followed by observations represented by X and  $O_c$  as before. This allows the effects of  $O_c$  and  $O_{Xvc}$  to be separated. It would also be necessary to include a control group that receives no treatment. (All groups referred to here are actually sets of group pairs.)

The design is represented by:

$$\begin{array}{cccccc}
 \begin{array}{c} 0 \\ \text{vc} \end{array} & \begin{array}{c} x \\ 0 \end{array} & \begin{array}{c} 0 \\ \text{Xvc} \end{array} & \begin{array}{c} x \\ 0 \end{array} & \begin{array}{c} 0 \\ \text{Xvc} \end{array} & \begin{array}{c} x \\ 0 \end{array} & \begin{array}{c} 0 \\ \text{Xvc} \end{array} & \begin{array}{c} x \\ 0 \end{array} & \begin{array}{c} 0 \\ \text{Xvc} \end{array} & \begin{array}{c} 0 \\ \text{vc} \end{array} \\
 \hline
 \begin{array}{c} 0 \\ \text{vc} \end{array} & \begin{array}{c} X \\ 0 \end{array} & \begin{array}{c} 0 \\ \text{c} \end{array} & \begin{array}{c} X \\ 0 \end{array} & \begin{array}{c} 0 \\ \text{c} \end{array} & \begin{array}{c} X \\ 0 \end{array} & \begin{array}{c} 0 \\ \text{c} \end{array} & \begin{array}{c} X \\ 0 \end{array} & \begin{array}{c} 0 \\ \text{c} \end{array} & \begin{array}{c} 0 \\ \text{vc} \end{array} \\
 \hline
 \begin{array}{c} 0 \\ \text{vc} \end{array} & & & & & & & & & \begin{array}{c} 0 \\ \text{vc} \end{array}
 \end{array}$$

This design, at least with respect to the prime experimental groups, is less amenable to remote data collection by telephone or with check-off forms. The development of the  $O_{\text{Xvc}}$  data collection method requires a thorough knowledge of the values involved and instrumentation/measurement problems. It would be necessary to regularly probe not only the apparent decision premises involved in each X, but also the underlying values tapped during each incident. This might best be done by an in-house researcher.

#### 4.2 - DEVELOPMENT OF JOINT PROJECT AND SELECTION OF FIELD SITES\*

As was already indicated in Chapter 1, the present study was performed as an activity of the LINCOTT project of Northwestern University's Program of Research on the Management of Research and Development. Thus, in its general approach to methodology and research design for investigating the coupling of task interdependent RDT&E groups, this study is related to others which are part of the LINCOTT project. In the present case, studies by both Barth and Douds examine the coupling of technical groups within R&D organizations. Both studies focus on the quality of communication between pairs of task interdependent RDT&E groups, thus directly addressing a theoretical need which provided the impetus for intensified effort of the Research Program in the LINCOTT area. This theoretical need, as stated in the Program's 1967 Annual Report,

. . . is for more understanding of the process of communication between organizational units, such as "research and marketing," "development and production," "systems planning and R and D." Although transfer of information is, ultimately, a process involving individual behavior and perceptions, there is much to be learned about this process at the aggregate level of communication between groups that may be linked or separated by many design features of the organization. (p. 14)

Initial explorations by Barth and Douds in their respective research area of interest and researchable questions led to a focus on similar sets of dependent variables concerned with the process of communication between organizational units. Similarly, each identified the task interdependence existing between such units as an important parameter. This indicated the possibility of conducting a joint field study, for if data could be obtained from the same set of respondents, not only would short term advantages for each dissertation be realized, but more importantly, the data could later be pooled for more exhaustive study as part of a LINCOTT project activity. It was decided to follow this course. Thus, both studies focus on the quality of the communication process existing between R&D working groups, drawn from areas such as research, development, testing, and engineering. The basic unit of analysis in each study is taken as a group pair consisting of two task interdependent groups. Also, both studies involve the level of task interdependence existing between the groups of a pair as a parameter.

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\* Jointly prepared by R. Barth and C. Douds

Separate efforts at defining sets of independent variables were involved in the respective writers' propositions. Douds focussed on the area of work related values, such as "to be creative, innovative, and imaginative," "to be persistent in one's work," "to be flexible in the technical approaches one considers," "to provide for maintainability and safety of design," "to present and discuss ideas with colleagues," etc. Barth focussed on the area of organizational climate for defining, for a given group pair, an intergroup organizational climate.

The respective models and testable propositions developed and formulated are complementary and supplementary to each other. This is an important part of the Research Program's over-all strategy, as indicated earlier in Chapter 2, and allows the two respective studies to be carried out as a single coordinated research project in the LINCOTT area. The fullest benefit can be derived from the two studies by sharing field sites and respondents, thus allowing data on the independent variables to be pooled upon completion of the individual dissertations.

In conjunction with these activities, instruments were designed in order to allow pilot studies to be carried out in the Chicago area. Details of this activity are presented in a later section of this chapter. In addition, a proposal covering several studies of the LINCOTT project, including the two discussed here, had been prepared and submitted to the Army Research Office. Several formal discussions followed. These were between Mr. Harold Davidson of the Army Research Office, Professor Albert H. Rubenstein, Principal Investigator of Northwestern's Program of Research on the Management of Research and Development, and other members of the Research Program. As a result of these discussions and an evaluation of the proposal, the Army Research Office provided support for carrying out studies on the LINCOTT phenomenon. Part of these funds provided direct support for this work, as did dissertation expense grants from the National Science Foundation to the writers, and support of the Program provided by the National Aeronautics and Space Administration. As one of the concurrent activities facilitated by this support, Barth and Douds attended a conference held from 2-6 June, 1969, at Airlie House, Warrenton, Virginia. Sponsored by the U.S. Army Materiel Command, this conference, "Seminar on Planning for Exploratory Development," provided participants with the opportunity to explore



ways to improve R & D management in the Quality Materiel Development Objective-based exploratory development phase of the materiel life cycle. Somewhat later, Bart also attended a conference on technology transfer held at Snowmass-at-Aspen, Colorado, and sponsored by the Denver Research Institute.\*

While these developments took place, considerable effort was also directed at obtaining the cooperation of a number of organizations from which appropriate group pairs could be drawn to participate in the field study. This endeavor was greatly enhanced and facilitated through the efforts of Mr. Harold Davidson of the Army Research Office, Mr. Walter A. Hahn, then with the Environmental Science Services Administration (ESSA), and Mr. Richard E. Stephens of NASA's University Affairs Office. Each of them suggested several organizations in their respective agencies. Initial contact with these potential field sites was established through a letter with a one page enclosure summarizing the purpose of the two studies. These are shown in Appendix 4A.

Four Army agencies, four ESSA laboratories, and three NASA centers expressed interest. All of these were subsequently visited one or more times in order to further explain the study to managers and laboratory directors and make the necessary arrangements for the selection of the groups. There were two major criteria for selecting which groups should participate. These criteria referred, first, to the requirement that the two groups of a given pair be task interdependent. Secondly, as would be expected on the basis of interdependence, some degree of communication exchange, whether effective or ineffective, had to be present. Across the field sites, we sought to identify, on the basis of managers' judgments, group pairs reflecting various combinations of level of task interdependence and communication exchange. In these discussions the researchers repeatedly stressed the confidentiality with which data would be treated.

Several other important functions were served by these visits. First, once the manager was tentatively satisfied that the topic of the study and the

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\* Formal proceedings of these conferences have been published. See U.S. Army Materiel Command, "Proceedings of the Seminar on Planning for Exploratory Development," Wash., D.C.,: Technical Planning Branch, Science & Technology Division, Research, Development & Engineering Directorate, Headquarters, USAMC, 1969; and Denver Research Institute, "The Environment and the Action in Technology Transfer: 1970-1980," report of a conference held at Snowmass-at-Aspen, Colorado, September 26-28, 1969.

researchers were not likely to be disruptive, he wanted to know how much time would be required of him and his people. He did not necessarily want to know what the total number of man-hours would be, but he wanted to know what "chunks" of time would be required, in what blocks or sequences, and when they would be required. Presenting this information required some care, not only because the managers expected fairly specific replies, but also because this information was usually requested early in the correspondence or conversation, and his decision state might still be tentative. He usually also wanted this information in a form that could be easily remembered to be conveyed to his superior or other managers and his subordinates.

Another purpose served by these contacts with managers was to identify individuals who would be involved as "gatekeepers," i.e., serve the critical and important function of providing, during the field study phase, a focal point of contact between the field researchers and respondents of a given site.

The final crucial point, which usually occurred beyond the middle of the negotiations, was the question of the specific utility of the study to the organization. The question, "Now what do we get out of it?" might be directly asked, usually implying the desire for specific findings about the organization. However, it did not turn out to be a basic issue. Undoubtedly the request would have been denied if managers did not see some kind of relevance or utility, but specific utility to the given organization was a negotiable point. When the question of specific utility was raised, the positive points of "learning better how organizations can be designed," "determining when a liaison function is needed and who can fill it," etc., were made, but the discussion was effectively ended by pointing out that providing too specific feedback would violate the confidentiality promise. Then potential arrangements to return after the conclusion of the study to make a presentation of the findings were discussed. The initiative for a specific invitation after the study was completed was left with the manager.

One government laboratory and two industrial R&D laboratories in the Chicago area participated in the pilot studies as described in Section 4.4. Eleven government laboratories and one large industrial R&D facility participated in the main data collection phase. The characteristics of organizations and of respondents are presented in Chapter 6. Field data collection procedures used are described next.

#### 4.3 - FIELD DATA COLLECTION PROCEDURES\*

One aspect of field data collection procedures is concerned with gaining access to the sites, selecting the participants, and scheduling the site visits. A second concerns the activities within a given site. In each site a principal contact, the "gatekeeper," was established to serve as a focal point for all arrangements. Usually, the gatekeeper functions were provided by two people--one who gave approval to basic decisions, such as which groups would participate, and initially introduced the researchers to other managers; and a second person who took care of schedules and other vital details.

Data collection took place from March into September, 1969, with field trips being made three weeks out of four, on the average. Scheduling site visits was complicated by the number of organizations participating and the understandable reluctance of the organizations to have both investigators collecting data simultaneously or for two weeks in succession. Questionnaire administration sessions and interviewing required about one week for each investigator and managers generally felt that the commitment of time to our project should be spread out rather than lumped together.

In a given site, group meetings were scheduled to explain the project and have questionnaires completed. One or several groups were present at these sessions. In every case but one, the combination of groups present at any given meeting did not include the group with which they were paired for the study. The overall purposes of the study were explained, clearly noting the funding of the study by the Department of the Army and NASA. The confidentiality of all responses was emphasized. This included describing the procedures utilized in the Program for the handling and storage of the data. The agenda for the session and general schedule of activities of the investigators at that site was described. Questions were encouraged during the discussion and at any time in the future, especially with regard to questionnaire items. A packet of material was given to each participant containing the general instructions and a summary of the project for him to keep, and the questionnaires were briefly explained. About 90 minutes were required for the session including completing the questionnaires.

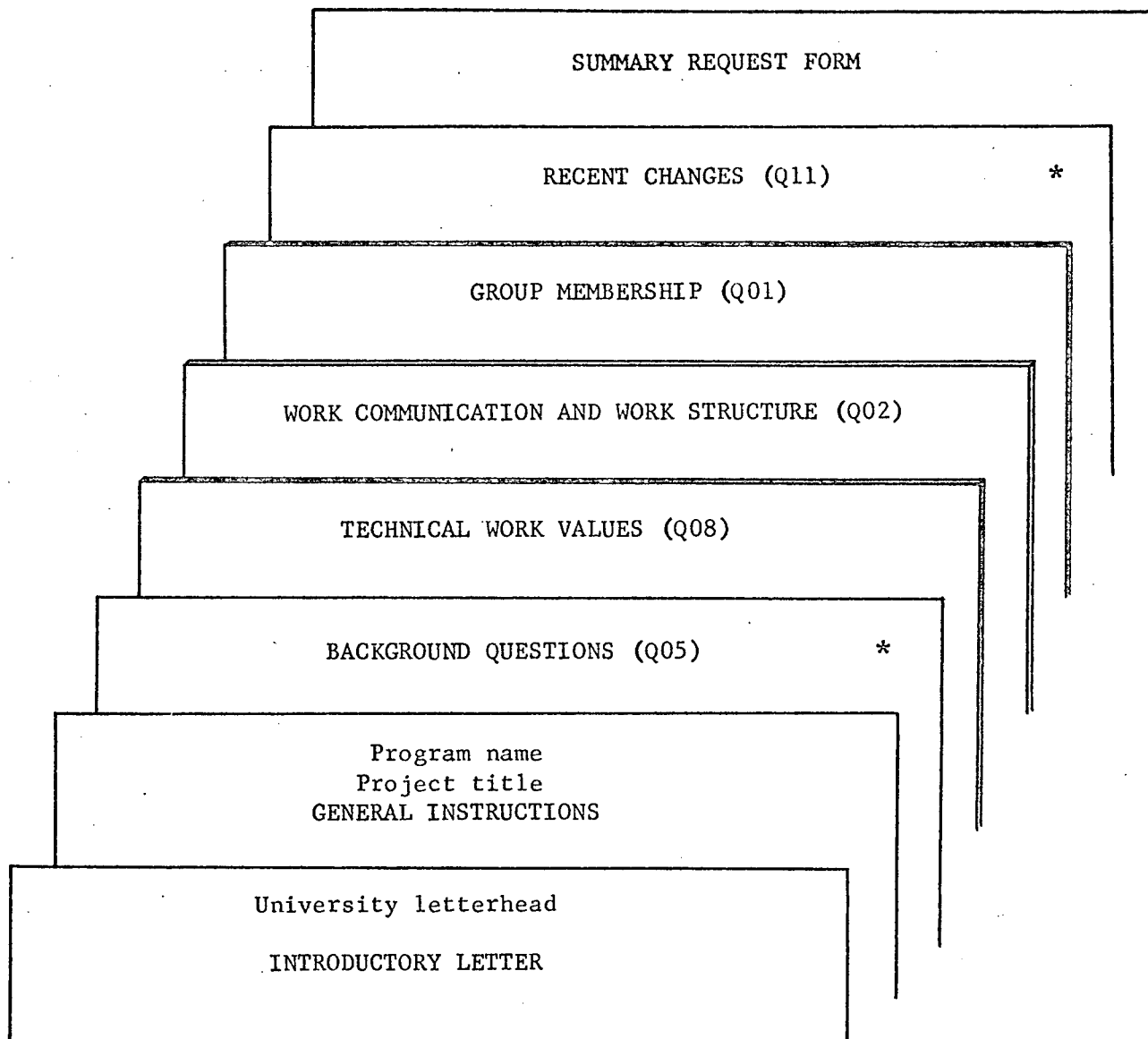
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\* Jointly prepared by R. Barth and C. Douds.

Cannell and Kahn (1953) discuss the design of an interview in terms of the "funnel approach" referring to a procedure of asking the most general or unrestricted questions first and then leading into more restricted questions. This approach was followed in assembling Douds questionnaire packet. The forms that the participants had the least difficulty with were placed first and the ones that were more specific and involved individuals were placed last. The very last item, to end on a rewarding note, was the optional request for a summary of the study. The packet structure is shown in Figure 4.3-1.

Interviews were then scheduled with the participants. Leaders from each group were interviewed by either Barth or Douds; in some cases by both. Interviews with group members lasted approximately one hour. Interviews were also scheduled with managers not members of either group, but who were knowledgeable about them and their joint activities.

During the group session it was explained that Douds would have a final, 15-minute instrument (the Q09) that would be based on their responses to the Values questionnaire (Q08). They received this instrument two to four weeks later. At four sites Douds returned in person to distribute the questionnaire early in the day and then picked it up later that same day. Very little follow-up was required when it was possible to do this. Barth took the questionnaire to two sites on trips he had scheduled for interviews. In those cases where it was not possible to return in person, the instrument was mailed directly to the participants with a stamped, self-addressed envelope inclosed. Follow-up calls were made after two weeks when necessary. In two organizations the gatekeeper's office did the actual follow-up based on information provided by the researcher. The instruments were always returned directly to the researcher.



\* Q11 substituted for Q05 when Douds followed Barth

Figure 4.3-1 - Douds' Questionnaire Packet Arrangement

#### 4.4 - PILOT TESTS

The questionnaires and other instruments described above were developed through use in other investigations, pre-tests, and pilot tests. This phase in the development of a research project receives little attention in publications of research findings and only rarely receives much attention in research methodology texts. (Adams and Preiss (1960), Festinger and Katz (1953), and Selltiz, et al (1965) are among the exceptions.) For the mature researcher a series of theses and dissertations by his students may constitute a form of pilot study for instruments or a theory he is developing, but the pilot test for a specific project serves a somewhat different function. The pilot test provides the opportunity to "have your failures safely." This is especially important to the student on his path to professionalism. The dissertation as a whole is a learning experience, as well as a rite of passage. The pilot test phase should create the confidence that the procedures used in the main data collection effort will provide the data needed and that the data will probably be useful in the subsequent analysis.

There are few specific instruments that are commonly used in organization theory studies, but programmatic research in a given institution provides the opportunity to make use of prior instruments or adapt them to the particular needs of a given study. Here we have already indicated the history of the development of the communication and group membership instruments which were derived from prior work on Phase II of Project HINDSIGHT. The present version of these instruments and all others were subjected to additional pre-tests and pilot tests. The temptation to rush through the pilot test, or omit it entirely, is strong, but it is of great importance.

The questionnaires were first pre-tested by having associates in the program fill them out and suggest changes in wording, format, or substantive content. Pilot tests were carried out in three organizations. During the pilot tests, the procedures for gaining access to the field sites and selecting the groups to be involved were developed, and various methods for administering the questionnaires and conducting the interviews were tried out. One experience will illustrate this process.

A major purpose of the pilot tests is to determine that the wording of items does not create errors and to ascertain that the instructions are clear, understandable,

and generate the desired behavior. This is accomplished by inviting questions and comments, asking the participants to make marginal notes, sitting with some individuals while they fill out a form and noting their pauses, hesitations, etc. But the effect of these errors on the data are minor compared to procedural effects that produce grossly distorted data or no data at all. The problem of gaining rapport is well-recognized (e.g., Festinger & Katz, 1953). Accordingly, plans were made to gather each group together, fully explain the study and provide specific answers to all their questions.\* This was done. In one particular case part way through the pilot study, a group was asked to complete the Values questionnaire (Q08) after the explanation session, and given the Work Communication and Work Structure (Q02) questionnaire to fill out and be picked up the next day. Upon returning, the researcher learned--before his coat was off--that the group was greatly upset, suspicious of his intentions, and otherwise feeling threatened by the questionnaire. The immediate situation was dealt with by further explanations and discussions with the managers involved as well as the people. (They did complete the questionnaires and participate in the interviews.) In subsequent sessions the obvious solution was followed of restructuring the explanations to better clarify the intent of the study, and the problem did not arise again.

For a different reason, another procedural change was made which we now see as also helping to avoid this difficulty. Near the conclusion of activities in the first field site of the main data collection effort, one group expressed a strong preference to complete all the questionnaires at one sitting. Of course, this had the advantage of reducing the amount of follow up required. Upon reflection, it appears that it also reduced the possibility of a group refusing to cooperate since there was little opportunity for feelings of suspicion to be interchanged. Potentially, someone could make a comment that would cause such problems. However, at the beginning of the questionnaire session the researcher encouraged the participants to ask questions whenever they had them, and stated that he would come to anyone while they were filling out questionnaires, "so as not to disturb the others." With this procedure, the problem that arose with the one pilot test group did not occur again.

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\* After some experience was gained many of the questions could be anticipated and answered in the presentation. It was found to be useful not to answer one or two of the more obvious questions to help insure that some questions came from the group.

#### 4.5 - DATA COLLECTION INSTRUMENTS

A variety of field data collection instruments and procedures were used during the course of the joint study. Some of the data was collected to be used in both studies. The data pertaining to the independent variables is unique to each study. Both structured and unstructured interviews were used, as well as several different types of questionnaires. The purpose of this section is to describe the basis of the data collection instrumentation, the structure and content of the instruments, and the reasons for changes that were made after completion of the pilot tests. The field procedures have already been described. Specific details on the number and type of respondents and their responses are presented in the following chapters.

The written questions were grouped into several questionnaires. Each questionnaire was given an identification code as well as an innocuous title. Some of the code numbers were carried forward from similar instruments used by the author in previous studies.

The instruments described in the following sections are:

| Section | Code      | Title                                    |
|---------|-----------|--|
| 4.5.1   | CD Int    | Manager's Interview I                    |
| 4.5.1   | CD Int    | Manager's Interview II                   |
| 4.5.1   | RB/CD Q10 | Group Activity Ratings                   |
| 4.5.2   | CD Int    | Respondent's Interview                   |
| 4.5.3   | CD Q08    | Technical Work Values                    |
| 4.5.4   | CD Q09    | Item Rankings                            |
| 4.5.5   | CD Q02    | Work Communication<br>and Work Structure |
| 4.5.6   | CD Q01    | Group Membership                         |
| 4.5.7   | CD Q05    | Background Questions                     |

Copies of all the questionnaires and forms are included in appendices. Appendix 4A includes cover letters and similar material. Appendix 4B contains the data collection instruments.



#### 4.5.1 - Manager's Interviews and Activity Rating\*

Manager's Interview I. During the period when arrangements were being made for the study and groups were being selected for participation, information was obtained from top level managers. Their titles were Director, Assistant Director, Division Chief, and other similar ones. Information was also obtained from their staff assistants. Interviews were conducted with 37 such individuals. During the first part of these interviews, the researcher explained the purpose of the study and the data collection procedures. The source of funding for the study was usually of considerable interest. The independence of the Program and confidentiality procedures were described in detail. In subsequent discussion, information was obtained on points such as the following, omitting those aspects for which adequate information had already been obtained.

- Types of work of the organization, division, etc. (as appropriate).
- Current major projects.
- Structure of the organization, division, etc.
- Activities requiring coupling with other units.
- Recent or forthcoming new projects.
- Recent or forthcoming organizational changes.
- The nature of the work of selected groups.
- Recent history of their work.
- Nature of their coupling with their counterpart.
- Impact of budget changes and manpower ceilings.

Background information and documents were obtained whenever possible during these interviews or later in discussions with staff members. Documents such as the following were sought:

- Official organization charts.
- Unofficial organization chart sketches for sub-units.
- Telephone directory.
- Procedure manuals.

Manager's Interview II. In addition to obtaining data for testing the propositions of Chapter 3, additional data was obtained from other sources a) to be able to relate it to other aspects of the effectiveness and productivity of the groups, and b) to be able to compare the perceptions of the group members to

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\* Jointly prepared by R. Barth and C. Douds.

perceptions of knowledgeable others. This data primarily concerned the effectiveness and productivity of the groups. It was obtained from managers who were not members of the groups, but who were knowledgeable about both groups of a pair. A short questionnaire, described below, was administered at the same time.

In the opening part of the interview, the same pattern was followed as described above. Since these interviews took place after the group meetings, the managers were already well aware of the points covered and so it was possible to cover them quickly. The interview covered the following points:

- the nature of their responsibilities
- the nature of their relationship to the groups
- their view of the relationship between the groups
- filling out the questionnaire
- discussion of the items.

Group Activity Rating. In order to relate both the independent and dependent variables to variables which might capture some of the important "consequences for the organization" (as perceived by managers), two instruments were constructed covering several aspects of the general effectiveness of the participating groups. These instruments (DB 10.1 and CD 10.2) were named "Group Activity Ratings" and are shown in Appendix 4B. In each of the participating organizations, managers having close knowledge of the groups participating from their organization completed these forms, thus providing independent summary evaluations. Typical job titles of these managers were Branch Chief, Section Head, Laboratory Director, etc.

On one form, identified as DB/10.1, a specific group pair was identified to the responding manager. Instructions asked for ratings of the "quality of relations" and "unity of effort" achieved by the group pair. A 7-point Likert type response format was used, ranging from "couldn't be better" (1) to "couldn't be worse," (7). The remaining four items on this form asked for separate ratings with respect to each group of the pair. In addition to the basic 5-point response format which ranged from "Not at all" (1) to "To a very great extent" (5), managers were also allowed to respond in terms of "Insufficient knowledge to reply" (8), or "Not applicable," (9). The items employed were the following:

3. To what extent are these groups innovative in their approach to the solution of technical problems?  
 Group (a) \_\_\_\_\_  
 Group (b) \_\_\_\_\_
4. To what extent are these groups successful in reducing target date uncertainty, i.e., uncertainties connected with getting the work completed on time?  
 Group (a) \_\_\_\_\_  
 Group (b) \_\_\_\_\_
5. To what extent are these groups successful in reducing technical uncertainty, i.e., uncertainties connected with whether or not a problem is solvable?  
 Group (a) \_\_\_\_\_  
 Group (b) \_\_\_\_\_

The other form, identified as CD 10.2, was utilized to obtain additional effectiveness/productivity data. On each form, one specific group was identified by name, and managers were asked to provide ratings according to how the identified group compared with others with which he had had experience in his present job or in other organizations. The response format was identical to that used for the items shown above. The particular items used were the following:

1. To what extent does this group effectively carry out its own work?  
 \_\_\_\_\_
2. To successfully do its work, to what extent is it necessary for this group to work with other groups:
  - 2) in their own department? \_\_\_\_\_
  - 3) outside their own department? \_\_\_\_\_
4. To what extent does this group actually work effectively with other groups:
  - 4) in general? \_\_\_\_\_
  - 5) in their own department? \_\_\_\_\_
  - 6) outside their own department? \_\_\_\_\_
7. To what extent is this group productive:
  - 7) for their department? \_\_\_\_\_
  - 8) for other departments that could or do find their work useful? \_\_\_\_\_
  - 9) for the organization as a whole? \_\_\_\_\_
  - 10) for (potential) customers or users outside the organization? \_\_\_\_\_

11. To what extent is the work of this group important to:

11) the major project(s) to which they contribute? \_\_\_\_\_

12) your present responsibilities? \_\_\_\_\_

13) the organization as a whole? \_\_\_\_\_

14. To what extent do you feel certain of these answers?  
(Exclude "8's" and "9's") \_\_\_\_\_

#### 4.5.2 - Respondent's Interview Guide

At least two members from each group of a pair were interviewed by either Barth or Douds. The purpose of the interview, shared by both researchers, was to obtain an understanding of the work of each group, a brief history of their projects and technical interrelationship, the interviewee's perception of their working relationship, and the nature of the coupling between the groups, including identification of any formal or informal coupling agents.

The interview was designed to proceed in a sequence that would help to establish rapport and to go from the more general, easily answered questions, to the more specific (Cannell and Kahn, 1953). The interview was semi-structured around a list of prepared questions given in the Interview Guide below. The interview began with a brief review of the purposes of the project and a reaffirmation of the confidential treatment of all information provided. Usually some knowledge of the technical work of the group had been obtained previously from managers or in interviews with other group members. A brief restatement of this was made in such a manner as to invite the interviewee to provide further details and discuss his work. This easily led into the questions listed in the interview guide.

The first set of questions dealt with the perceptions of the respondent as to what was important to him, his group, and the other group of the pair, in doing their work. The nature of the coupling between the groups was explored. Then differences in the viewpoints of the two groups were probed after a transition statement indicating that such differences were natural and to be expected. The following questions dealt with various aspects of the communication process between the groups. Frequently, these questions would have been spontaneously answered earlier by the interviewee.

## INTERVIEW GUIDE

Statement: Research project and confidentiality.

Discuss group's work.

1. In doing your work what kinds of things are important to you?
  - 1A What is it that leads you to prefer one project/assignment/job over another?
  - 1B What makes a job interesting?
  - 1C What is it that makes you feel that a job has been a success?
2. Do you think most of the people in the group here feel the same way?
  - 2A How do they differ?
3. How does their work relate to yours?
  - 3A What do you do for them?      3B What do they do for you?
4. How closely do you have to work with them? How often? How important?
5. What does the (Referenced Group) seem to emphasize in doing their work, as you see it?
  - 5A What sorts of things are important to them?
  - 5B On what do they base their decisions . . . their actions?
  - 5C What makes their work a success in their eyes?
6. (Lead in - similarities and differences) What do the differences in viewpoints between their group and yours (this group) seem to be?
  - 6A . . . . About what is important to consider in looking at a problem?
  - 6B . . . . About priorities in what to do first (or when)?
  - 6C . . . . About what to do, or how to do it?
7. How useful or disruptive are these differences in viewpoint?
 

How so? In what ways?
8. When it comes to working together with them or getting information from them, what is your feeling about these items . . .
 

|                      |                                       |
|----------------------|---------------------------------------|
| 8A . . . time delays | 8C . . . changes (in specs, in goals) |
| 8B . . . indecision  | 8D . . . inaccuracies                 |
9. To what extent do they voluntarily send things (articles, reports) your way, or tell you about interesting events or developments?
10. To what extent do they keep you posted as to what is going on? At least with respect to those things that might be of interest to you?
11. Now I want to ask a difficult question. (Explain.) Not considering the particular technical knowledge that the people in the other group have, or particular organizational position they may now have, in your best judgment, who is the best single person to work through in the other group for the day-to-day aspects of getting the work done? Who is the best "coupling agent" or "liaison man?"
12. Again, not considering technical knowledge or organizational position, per se, who is the best person here for them to work through on the day-to-day problems of getting the work done?

Concluding summary and thanks.

The final topic sought to obtain judgments as to who were the most effective coupling or liaison agents. An extended introduction had to be given and the question carefully framed. People frequently tended to interpret the question as asking for an over-all judgment of the competence of their associates, or they interpreted the question as referring to a judgment of technical proficiency.

It was usually possible to complete the interview within one hour.

#### 4.5.3 - Work-Related Values

The independent variables in several of the propositions to be tested were based on the importance of work-related values to members of working groups. This information was also used to determine a reduced list of items as described in the next section.

Selection of Items. Two methods were considered for obtaining the value items to be used. One was to develop them from the population of interest, using variations of techniques developed by Milburn, et al (in process)--the "Echo" technique--, and Triandis, et al, (1968)--the antecedent-consequent technique. A third technique, a variation on the Critical Incident Technique (Flanagan, 1961), was incorporated with the other two in a preliminary pilot test conducted by Dr. Stephen C. Hill\* and the author. One disadvantage of these techniques is that they require a numerically large population and several time consuming cycles to arrive at a useful and stable set of items. Since the techniques are new, a great deal of effort would also be required to establish their validity. The limited trial conducted made these points clear and so this approach was not used.

The method used was to draw items from the literature and prior field work. The categories and sources of the items have been discussed in Chapter 3. We sought to tap a variety of values likely to be relevant to engineers and scientists in non-academic work environments. Items were sought that would fit into one or more of the following categories appearing in the literature: science values, engineering values, professional values, contributing to

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\* Post-Doctoral Fellow, Department of Industrial Engineering and Management Sciences, Northeastern University, 1967-1969.

knowledge and society, theoretical understanding vs. "practical" output, autonomy, group relations, work challenge, career advancement, and personal behavior values. Eighty items were selected for use in the questionnaire. The items and the item numbers as they appear in the final questionnaire (Q08.3) are shown in Table 4.5-1. Two versions of the instrument, differing in their method of scoring, were used as described below.

First Version. In the first version of the instrument a primary objective was to have a procedure that would provide the reduced set of items needed for Q-sorts. These were to be performed during interviews shortly following the first administration of questionnaires. Two identical sets of 80 items were created, differing only in order of presentation (both random). One was identified as Q08.1 and the other as Q08.2. Both were included in one instrument with 20 items per page and the following instructions:

#### TECHNICAL WORK VALUES

We would like to determine which of the following items are important to you (Part A) and your immediate group (Part B). On each page please mark the five items that are most important to you or your group as indicated.

Item choice frequencies could be quickly tabulated by groups and group pairs. Pilot tests showed that the instrument could be completed quickly by the respondents with little difficulty. No more than 15 minutes was required for the total of 160 items with 5 choices made per page. A few respondents commented that on some pages they wanted to pick more than 5 items and on some pages less. A very few actually did so. This version was used in the pilot studies and the first two organizations in the main study.

Second Version. The format of the questionnaire was revised when it became apparent that not enough time would be available at each field site to administer the follow-up questions personally to each respondent. A conventional multiple choice response format was used with the following five-point scale:

- 4 - extremely important
- 3 - quite important
- 2 - moderately important
- 1 - slightly important
- 0 - not important, irrelevant

The key line of the instructions establishing the context for response is, "In order to do your kind of work well in this group, how important are each of the following to you?"

Table 4.5-1 - Technical Work Value Items

## SCIENCE VALUES

- 30. To discover general principles that apply to many situations.
- 71. To probe deeply and thoroughly into technical/scientific phenomena.
- 28. To fully report the sources of one's ideas.
- 7. To be dedicated (rather than ambitious).
- 52. To objectively - not subjectively - judge technical or scientific work.
- 18. To be persistent in one's work.

## CONTRIBUTIONS TO KNOWLEDGE AND SOCIETY

- 46. To contribute to broad technical knowledge in one's field.
- 51. To work on problems of great value to the nation and society.

## PROFESSIONAL VALUES

- 26. To make technical or scientific knowledge openly available to the scientific/technical community.
- 74. To be a member of one's professional community outside the organization.
- 35. To build one's professional reputation.
- 16. To be creative, innovative, imaginative.

## THEORETICAL VS. PRACTICAL VALUES

- 6. To fully develop ideas theoretically before trying them in practice.
- 48. To have an academic orientation - theoretical, analytical.
- 31. To have an application orientation - pragmatic, empirical.
- 73. To compromise, rather than do exhaustive research, analysis, or development.
- 21. To subject ideas to practical trial as soon as possible.
- 14. To work by cut-and-try methods.
- 75. To get quick solutions.
- 58. To get acceptable results, adequate to do the job.

## ENGINEERING VALUES

- 76. To have simplicity of design or approach.
- 27. To refine a design: to make it the best possible.
- 8. To provide functional utility of design.
- 45. To provide for manufacturability of design or "implementability" of approach.
- 69. To provide for maintainability of design.
- 12. To have reliability of design.
- 24. To provide for safety of design.
- 11. To design for quality control.
- 32. To do rigorous testing.
- 5. To attain stated specifications.
- 15. To exceed technical specifications.
- 43. To be efficient in one's work.
- 10. To meet delivery schedules.
- 39. To reduce total project costs.
- 79. To consider trade-off possibilities.
- 61. To use proven techniques or items.
- 77. To have innovative designs or approaches.
- 68. To have sophistication of design or approach.
- 62. To have aesthetic appeal of design.



Table 4.5-1 - Technical Work Value Items (cont'd)

## GROUP RELATIONS VALUES

- 37. To have congenial co-workers or colleagues.
- 57. To anticipate the wishes of one's group before acting.
- 20. To act as one believes, regardless of contrary opinion.
- 72. To promote the welfare of one's work group.
- 54. To be loyal to one's work group.
- 36. To have similar interests - sports, religion, politics, etc. - to one's group.
- 44. To be loyal to one's organization.
- 55. To help others.
- 3. To be able to lead and control.
- 33. To work with things more so than with people.
- 59. To be flexible in the approaches one considers.
- 22. To work with colleagues of high technical competence.
- 50. To present and discuss ideas with colleagues.
- 25. To learn and develop through interactions with colleagues.
- 9. To develop technical competence in others.

## WORK CHALLENGE VALUES

- 19. To work on difficult and challenging problems.
- 80. To bring order and simplicity in chaotic or complex material.
- 34. To have a sense of mission for one's projects.
- 63. To have a sense of mission for science or technology.
- 2. To know how others are progressing on their work.
- 13. To make full use of one's present knowledge and skills.
- 40. To know why things are being done the way they are.
- 42. To work on problems for which there are ready-made solutions.

## AUTONOMY VALUES

- 78. To have freedom to choose how one will carry out his work.
- 49. To have freedom to carry out one's ideas within project objectives.
- 23. To have freedom to choose what one will work on.

## CAREER ADVANCEMENT VALUES

- 47. To advance oneself economically.
- 70. To advance and move ahead in organizational position.
- 64. To have social status and prestige.
- 56. To have a stable, secure future.

## PERSONAL BEHAVIOR VALUES

- 1. To have emotional neutrality - keep one's emotions in check.
- 67. To have understanding or sensitivity.
- 65. To have self-discipline.
- 66. To have tolerance.
- 53. To have enthusiasm.
- 29. To have a sense of humor.
- 4. To be sociable.
- 60. To be unselfish.
- 41. To operate ethically.
- 38. To be conscientious.
- 17. To be sincere.

The revised instrument is identified as CD Q08.3 and is included in Appendix 4B. The time for administration remained the same--from 10 to 15 minutes with most respondents finishing it in about 12 minutes.

#### 4.5.4 - Values Ranking

Several of the variables in the propositions involve comparisons of work-related values as perceived by the respondents in various contexts. The data from which the indices for these variables are derived is provided by the respondent's rank ordering a set of value items three times.

Selection Algorithm. Three separate rank orderings are required of each respondent. Because of the length of the list and the repetition of the sorting procedure, "instrument decay" would be an important threat to internal validity, (Campbell and Stanley, 1966, p. 9). Consequently, a reduced list of items was used.

In selecting the items it was desired: 1) to allow actual dissimilarities to clearly emerge when they exist; 2) to allow projection of one's own values upon the other group to emerge as clearly as possible when that condition obtains; 3) to avoid the use of items about which there would be considerable variation of response within a given group; and 4) to provide a means for comparing the responses of all groups in the study.

The last criterion would be satisfied by using the same set of items for all groups. (This would also have allowed all questionnaires to be completed at the same time.) However, this would make it much more difficult to satisfy the first three criteria. If items were picked to satisfy #3, (low variance in the population as a whole), this would mitigate against satisfying #1 and #2. Further, only a limited amount of data was available from the pilot tests (and this did not include any data from scientists), so there was not adequate information to pick a set of items. Consequently a fixed, predetermined set of items was not used. The items were selected on the basis of the responses of each pair of groups.

The following criteria were applied to pick the items from the responses to Q08 of each pair of groups:

- 1) Items with a high variance ( $\sigma^2 \geq 1.0$ ) were eliminated from consideration.

- 2) The five items for which there is the greatest disparity between the groups are selected.
- 3A) Five additional items from the upper quartile that are not in the upper quartile of the other group are selected.
- 3B) The above procedure (3A) is repeated for the other group. When there was not a total of five items remaining that met the criteria of 3A and 3B, items were added pairwise extending into the next quartile until five items for each group were obtained.
- 4) An identical set of five items--"markers"--were added to the set of Q09's for every pair of groups in the study.

Lists of items were prepared for each group, rank ordered by mean score, and for the pair of groups, rank ordered by the difference in mean scores for all eighty Q08 items. The lists were prepared by a computer program.\* The items were selected manually since it was not deemed worth the greatly added effort to do the programming to handle the not too frequent ties. Ties in #2 would have been broken with a random choice if they had occurred. Ties occurring at the quartile division were handled by including all the tied items. A total of 20 items was always selected.

Prior to the use of the Q08.3 format, the items were selected by combining the frequency counts from Q08.1 and Q08.2 for all group members and making the selections on the basis of response frequency, normalized by the number of persons in a group. An added advantage of the Q08.3 format was that it allowed the high variance items to be identified and eliminated in creating the Q09 list.

The use of "marker" items allows comparisons to be made between different sets of judges rank ordering different, but comparable, sets of items. The procedure is described by Moses, Brady, et al (1967). The inclusion of marker items will allow additional information to be extracted from the data in post hoc analysis. A stable set of marker items (low variance) distributed across the range of possible responses is required. On the basis of the responses obtained during pilot studies the following items were selected as "markers:"

- To refine a design; to make it the best possible.
- To present and discuss ideas with colleagues.
- To have emotional neutrality - to keep one's emotions in check.
- To develop technical competence in others.
- To get quick solutions.

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\* Program WORKVAL given in Appendix 4C.

"Q-Sort" Version. The Q-sort technique has a number of applications as described by Stephenson (1953) who developed the technique. While Stephenson used the term in a special sense, it has come to be applied more broadly to having a respondent sort a set of cards bearing words, phrases, or statements into a number of categories (as in Stephenson's procedure) and then possibly rank-order the cards within the categories (e.g., Kerlinger, 1965). In an interview situation this procedure has the added advantage that the respondent often becomes more involved in the interview and freely provides additional relevant information. This procedure was used during the early phases of the study. Three sorts, of the 20 cards selected as above, were made following instructions described in the next section. The final version, described below, provided exactly the same data and did not have to be individually administered.

Final Version. The final version of the instrument used in the study was a paper-and-pencil questionnaire: CD Q09, "Item Rankings." The set of 20 items selected is repeated three times, in different random orders, with three sets of instructions. The first task presented (Part A) is for the respondent to rank order the value items by their importance to the other group as he perceives them. The second task has the respondent rank order the values by their importance to himself. The third task (Part C) requests the respondents to rank order the items as their "ideal" associate would do. When the data for respondents in each group is combined, these allow comparisons to be made between the groups in the various ways required by several of the propositions to be tested.

These instructions are very similar to those used by Hill (1967) in his questionnaires and Q-sorts for science values and interpersonal behavioral values. The greatest difference is in Part A, since Hill was dealing with the individual and his working group, whereas we are dealing with the relations between an individual in his group and another group, or one group as a whole and the other group.

One advantage of the Q-sort technique is that it allows the respondents to more easily perform a rank ordering by first sorting the items into ranked categories and then ranking the items within categories. It is more awkward to do a rank ordering of many items on a printed page. This difficulty was successfully circumvented by asking the respondents to score the items from 0 (low importance) to 99 (high importance) and to make sure that no two numbers were

the same. With five times as many "points" available as items to be ranked, the respondent could indicate gaps or clusters if he so desired. These numbers are easily compressed to a 1 - 20 rank order scale for use with conventional rank order statistical methods.

The general instructions and a sample Q09 questionnaire are presented in Appendix 4B. Approximately five minutes were required to do each part. The instructions for the three parts are:

#### PART A

##### REFERENCED GROUP

Assign numbers from 0 (least important) to 99 (most important) the way you think the people in the Referenced Group would do so. Make sure no two numbers are the same.

#### PART B

##### SELF

Assign numbers from 0 to 99 indicating importance to you. Make sure no two numbers are the same.

#### PART C

##### IDEAL ASSOCIATE

This is a hypothetical situation. In a new organization of which you are a part, you are doing exactly the kind of work you would like to do. You are to hire an associate to work with you. He will be available as much or as little as you need him. Assign numbers from 0 to 99 the way you think the ideal man for this position would do so.

#### 4.5.5 - Communication and Task Interdependence

The coupling process between R&D groups involves communication of task relevant information bearing on needs, problems, solutions, etc., and is affected by the task interdependence of one group upon the other. Questionnaire CD Q02, "Work Communication and Work Structure" was designed to provide measures of the perceived properties of communication and task interdependence of one group with another. Closely related to the information exchange process is the decision making process involving the pair of groups and the level of conflict or cooperation in their joint activities. Variables pertaining to these topics are dealt with by Barth in his parallel study for this project.

The conceptual basis of the communication portion of the instrument has been described in section 3.2, and the task interdependence portion in section 3.3. The evolution of the instrument and its items began in the fall of 1965 with Phase II of Project HINDSIGHT conducted by the Program of Research on the Management of Research and Development with support from the Office of Naval Research.\* One aspect of the Phase II study dealt with the coupling of technical groups involved in the development of certain successful weapon systems. An instrument was constructed by this author to determine characteristics of the communication process involved. It was pilot tested and modified by the writer and Daniel Kegan during the winter of 1966 in several R&D organizations in the Chicago area as a part of a class in field research methodology. The final version appeared as instrument III.3 in the Project HINDSIGHT Field Manual (1966). Data was collected in a number of industrial and aerospace organizations by cooperating staff members of those organizations. The data was later reduced by Mills (1967). In 1968 the instrument was revised and pilot tested in an aerospace organization by the author for a proposed study of the communication of design change information. The present version was developed from its predecessors taking into account the information learned from R&D managers and engineers, so that now it incorporates multiple questions dealing with the various critical facets of the communication process in R&D projects.

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\* Phase II work on Project HINDSIGHT is described in Rubenstein (1966b).

Communication Items. There are four types of items in the questionnaire pertaining to communication and information exchange between the respondent's group and the other group selected for the study (the "Referenced Group"). These are: a) frequency of communication, b) number of channels,\* c) perceptions of the characteristics of the information transferred between the Referenced Group and the respondent's group, and d) the respondent's perception of what the Referenced Group would claim about the characteristics of information transfer from their viewpoint. The last type of question will be explained more fully below. This type might be called "reciprocal" or "mirror" questions and allows a second measure of communication to be constructed.

Questions 1 - 4 pertain to frequency of task-related communication for the respondent individually (2), and his group as a whole (1, 3, 4). The last two questions focus on communication of changes in task activity. An eight point response scale ranging from "Several times a day" to "Never" was provided.

The items are:

1. How often does your group talk with people from the Referenced Group about the project, or technical work?
2. How often do you personally talk with people from their group about the project, or technical work?
3. How often does your group attempt to learn from them about changes being made or proposed in their work which might affect you or your group?
4. How often does your group receive information from them about changes being proposed or made in project or technical work relevant to your group's responsibilities?

The relative number of channels originating from each group were determined with the following questions:

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\* "Channels" is used here as in Thayer (1968, p. 131), "Channel (refers) to any specialized, functional communicative link and/or chain between or among people--whether those linkages have evolved through use or have been formally established for task-related data flows through an organization or enterprise."

12. To what extent are the communications with them handled by  
 . . . one or two people from your group?

versus

13. . . . all the people from your group?

21. To what extent are the communications with them handled by  
 . . . one or two people from their group?

versus

22. . . . all the people from their group?

The remainder of the questions provide various indicators of the respondent's perception of how "effective" the task-related communications or information exchange between the groups are--more precisely, the level of problems in communication. Problems in communication may manifest themselves in a variety of ways suggested in earlier discussion. Three questions concern time lags in receiving needed information.

5. When your group asks them for information, how long does it usually take to receive it?
6. When you ask them for information relevant to making a change on some item or aspect of the project, how long does it usually take for your group to receive a specific answer from them?
7. When they make a change in their work that significantly affects you, how long does it usually take for your group to find out about it?

The six response categories (plus "Does not apply") are phrased in terms of delays relative to when the information is needed--not the over-all time lag which would be highly variable depending upon the subject matter..

Three questions concern continuing up-dating on work status, expected goal achievement, and expected support. These questions are paralleled by "reciprocal" questions ("we" and "they" referents reversed) as mentioned above. These questions, which are not used in computing the primary "communication problems" score, are identified here by an asterisk:

9. How adequately is your group informed on the status of those aspects of their current activities relevant to your work?
- \*67. How adequately are they informed on the status of those aspects of your group's current activities relevant to their work?
10. How adequately is your group informed of what they expect to achieve and by when?
- \*68. How adequately are they informed of what your group expects them to achieve and by when?



11. How adequately do you know what they expect of you in doing your work?

\*69. How adequately do they know what your group expects of them in doing their work?

Two questions, with reciprocals, pertain to "feed-forward"--letting the other group know in advance that something unusual or different than planned is going to happen. This is an important part of the communication process in that it often allows the recipient to get into the decision process, if he wishes, before commitments are fully made by the originator.

17. To what extent do they make requests for information that come unexpectedly to your group (and require significant effort to fulfill)?

\*70. To what extent does your group make requests for information that come unexpectedly to them (and require significant effort to fulfill)?

18. To what extent do they make changes affecting your work that come unexpectedly (and require significant effort)?

\*71. To what extent does your group make changes affecting their work that come unexpectedly to them (and require significant effort)?

One question essentially involves the syntactic and semantic levels of communication in that it concerns clarity of content:

19. When you receive requests, recommendations, instructions, or other such information from the other group, generally to what extent is it clear as to what is needed, what to do, etc.?

\*72. When they receive requests, recommendations, instructions, or other such information from your group, to what extent do they seem to understand what you need, what they are to do, etc.?

A pair of questions concern restriction in the amount of information provided (expressed as "completeness") and the accuracy of the information provided. Again the questions focus on changes in work because they are presumably more sensitive and more revealing of the quality of the communications between the groups. Communication between groups when everything is going as planned are probably highly redundant and can appear to be quite good. The information that requires new decisions is the non-redundant information concerning departures from the norm.

36. When CHANGES in work or a project are being considered with them, how doubtful is it that the information is as complete as your group needs it?

37. When CHANGES in work or a project are being considered with them, how doubtful do you tend to be of the content provided on key issues--that it is as accurate as it can be at the time?

Five summary questions were provided after the task interdependence questions and with a different response format to provide a cross-check on the more specific questions above. The first two deal with accuracy and completeness, as above, but this time without reference to a specific type of situation.

62. In terms of your group's needs, how accurate has the content of what they tell your group usually turned out to be - how well has it reflected the situation discussed?
63. In terms of your group's needs, how complete has the information provided by the other group turned out to be - do they usually provide all the information available to them which you need?

The perceived utility of the information provided, the scepticism with which it is accepted, and an over-all assessment of the inter-group communication are obtained with these questions:

64. In terms of your group's needs, how useful is the information they provide to your group?
65. If they were to make a somewhat unusual request or provide a somewhat unexpected response to you (in their assigned area of responsibility), if the item were of concern to you, to what extent would you seek to confirm it?
66. What is your individual over-all evaluation of the effectiveness of the communications between your group and the other group?

Bias Controls. Response set bias (Guilford, 1954), arising from the physical format, was minimized in the questionnaire by providing sets of numbered response categories for blocks of questions that could be answered with the same set of adjectives. (See the complete questionnaire in Appendix 4B.) In addition, eight items were worded so as to require reverse scoring for consistency (items 9, 10, 11, 19, 67, 68, 69, 72). Null responses ("Does not apply") were provided wherever appropriate--in particular for groups with low task dependence--to avoid developing a tendency for non-responses. The mean item non-response rate was under 2%.

Items 62-66 required differently worded response categories for each item so the format used elsewhere in the questionnaire was changed. The response scale was arranged horizontally under each scale. The physical location of the "good communication" end of the scale was selected at random by a coin-flip for each item. It so happened that only 65 was reversed. Accepting this chance pattern ultimately proved to be a mistake.

Aware that these 5 items were prone to response set bias, the researcher specifically checked them during the pilot tests. No difficulty was encountered. The responses were consistent with interview data; they were consistent with similar questions elsewhere in the questionnaire; and there were reasonable variations among the five. About half way through the field study one person, in a group already known to have good relations with their Referenced Group, was observed marking the "poor" end of the scale. Asked about the same question later, he gave a contrary reply. Inspection of the completed forms indicated considerable inconsistency.

This is an example of response set bias arising from physical format. The fact that question 65 is longer than the others may have contributed to the difficulty, but it is more likely that by the time the respondent had done three questions with the "good" end of the scale on the right, he did not pay attention to the adjectives. Since only one item of 16 contributing to a single scale was involved, this item was not included in the analysis. The discriminations made among the remaining items are considered in the section discussing the perceived communication problems scale.

Task Interdependence Items. The concept of task interdependence was discussed in Sections 3.2.4 and 3.2.5 in terms of the effect of the activities of one group upon the activities of another. Four forms of task interdependence were described--work initiation and influence, input/output dependence, mutual dependence, and advisory or consulting dependence. A set of questions designed to provide indicators for measures of these dimensions of interdependence was incorporated in the "Work Communication and Work Structure" questionnaire (CD Q02).

The dimension of Work Initiation and Influence involves information and decisions coming from one group to another that start them working on new tasks or provide approval and possible redirection of their current activities. This dimension is tapped with the following seven questions:

26. We have to "finish" a major task before they can go very far on a major task they have to perform.
31. We have the responsibility to check or approve items, designs, recommendations, or actions made by others on the project.
32. They work on relatively short term activities at our request.
34. They work on long term activities originating from us.
58. In order for your group to adequately perform its work on this project, to what extent does the Referenced Group need to make use of rulings on specific points, formal direction, or authorization provided by you?
59. In order for them to adequately perform their work on this project, to what extent do they need to: Make use of your regular technical output--e.g., designs, hardware, software, test facilities/results, documents, drawings, etc.?
60. In order for them to adequately perform their work on this project, to what extent do they need to: Receive or obtain rulings on specific points (e.g., permission to use a specific material), formal direction, or authorization from you?

The response categories for these questions, and all others in this section unless otherwise noted, were:

1. Not at all
2. To a very little extent
3. To some extent
4. To a considerable extent
5. To a very great extent

The dimension of Input/Output Dependence was measured with the following eight questions serving as indicators:

25. They have to "finish" a major task before we can go very far on a major task we have to perform.
30. They have the responsibility to check or approve items, designs, recommendations, or actions made by others on the project.
33. We work on relatively short term activities at their request.
35. We work on long term activities originating from them.
53. In order for your group to adequately perform its work on this project, to what extent does your group need to:
  - Make use of their regular technical output?
54. -- Receive or obtain rulings on specific points, formal direction, or authorization from them?
56. In order for your group to adequately perform their work on this project, to what extent does the Referenced Group need to:
  - Be informed of activities you are responsible for or be informed of your specialized knowledge?
57. -- Make use of your technical output?

The primary feature of the Mutual Dependence dimension is that two groups are working on different aspects of the same project at the same time with an attendant necessity for information exchange and joint decision making if both are to attain their goals. The concurrent or parallel work aspect was determined with these three questions:

27. Both of us must work concurrently. (perhaps because each needs information from the other to complete their respective assignments, or perhaps because possible trade-offs can importantly affect the success of both groups).
55. In order for your group to adequately perform its work on this project, to what extent does your group need to:
  - Work in parallel with them - exchanging information and deciding on things together?
61. In order for them to adequately perform their work on this project, to what extent do they need to:
  - Work in parallel with you - exchanging information and deciding on things together?

The necessity for information about current status, action expectations, and goal attainment expectations was determined by five questions, two of which are given in "reciprocal" form ("we" and "they" referents reversed) to determine mutual

dependence. Comments received during the pre-pilot development of the questionnaire indicated that the reciprocal form of #16 was confusing and so it was dropped.

14. To what extent does your group need to know the status of their current activities?
23. To what extent does their group need to know the status of your group's current activities?
15. To what extent does your group need to know what they expect to achieve?
24. To what extent does their group need to know what your group expects to achieve?
16. To what extent does your group need to know what they expect of you?

In addition to the above two pairs of questions, that are "reciprocal," several others are also in this form. The interdependence questions are relatively straight-forward, in that they mostly deal with work routines, task sequences, and organizational procedures. The reciprocal questions can be used separately to determine structural clarity--how clear or unambiguous the work flow relationship between the groups is--for the pair of groups, or how well informed individual respondents are of the working relationship.

The final dimension of Advisory and Consulting Interdependence was determined with the following two reciprocal questions. Note that they exclude advice and consultation coming about from work on the same project. When groups work on the same project they may get involved in technical discussions which could be interpreted as "advice or consultation." We wanted to exclude responses from this source in order to reveal those groups with low interdependence that nevertheless have an active coupling process taking place.

28. They provide us with advice or information not generated specifically for the project(s) we work on.
29. We provide them with advice or information not generated specifically for the project(s) they work on.

One question of an exploratory form was included to test a possible measure of over-all dependence. The concept involved is that closely-linked groups that are highly dependent upon each other frequently receive work, information, or decision inputs from the other that are important to their own adequate

performance of their activities. If these inputs were suddenly to become unavailable, it would not be long until they would need them and would have to do the work of the other group or see that it was done. On the other hand, if a pair of groups were not very dependent upon each other it would be a much longer time before cessation of their inputs from one group to the other would affect the latter's activities. This concept was put in the form of a hypothetical question:

8. Assume that for some reason suddenly no information were available from the other group to anyone - in essence, they ceased to exist.

What is the longest time your group could wait without too much disruption to its normal work before you or someone else would have to begin doing their work - or at least that part of it which pertains to your group?

- |                       |                          |
|-----------------------|--------------------------|
| 1 - One day or less   | 4 - Three months or less |
| 2 - One week or less  | 5 - Six months or so     |
| 3 - One month or less | 6 - A year or longer     |

During the pilot tests several respondents were asked to discuss this question. Their responses indicated that their thinking was consistent with the intended function of the question. During the main data collection phase, a few comments were received, and some responses inconsistent with other data were noted, that indicated the questioning was not functioning as intended for these respondents. It was not used as an index of interdependence, but it will be explored further at a later time.

Other Items. A few additional items concerning respect for the Referenced Group, types of pressure, and activity goals were included in this questionnaire.

One indicator of the "respect" variable was also included in this questionnaire. The wording follows that of Kahn, et al (1964, p. 437) with appropriate modification for reference to a group rather than individuals.

20. We all respect the knowledge and judgment evidenced by the actions of some groups more than others. To what extent do you have this kind of respect for their group?

Several items identifying eight potential reasons for one group exerting pressure on the other group were added to the final version of the questionnaire to indicate some task-specific reasons for communication problems. The communication problems measure should also discriminate against these items if the construct has validity. A five point scale from "No pressure at all" to "A great deal of pressure" was used with the items:

How much pressure does your group feel from this group to:

38. Generally increase performance - the quality of work you are responsible for on the project.
39. Generally work more efficiently on the project.
40. Provide your work output sooner.
41. Help with problems on the project.
42. Minimize changes in the project.
43. Meet tighter specs or more difficult goals.
44. Reduce dollar costs.
45. Change certain characteristics (specs, design) of what you are now working on.

The respondents were also asked to rank order the first seven of these items on the basis of their importance to themselves in their present work. This provides a limited basis for comparing specific task value orientations of the individuals and can provide a limited comparison to the Q09 responses.



#### 4.5.6 - Group Membership

When doing research on groups in organizations knowledge of the group composition and structure is needed. Questionnaire CD Q01, "Group Membership," provides this data and information needed to indicate the level of respect for the Reference Group. This instrument also evolved from instrument III.3 of Project HINDSIGHT which was developed by the author. The "worksheet" format was used in that study. The present instrument is based directly on a modified version used in a pilot study for a research proposal concerned with the effects of technical uncertainty and design change. The questions and format are based on the "Personal Contact Checklist" used by Jacobsen and Seashore (1951). The respondent is asked to identify those people whom he considers to belong to his immediate work group or team and those people whom he thinks of as belonging to the Referenced Group.

Five questions are asked about each person as follows:

FREQUENCY - your typical frequency of contact with him whether initiated by him or you.

STATUS - the status of his organizational position relative to yours.

EXPERIENCE - his depth or extent of technical experience in the type of work he is now doing.

CLOSE FRIEND - check any persons you would consider as close personal friends of yours.

ESTEEM - follow the instructions on the page following the Worksheet where you will construct your own "thermometer."

Eight response categories are provided for frequency, three for status, five for experience, and a binary choice (check mark or blank) for close friend. The respondent created a self-anchoring scale for esteem.

The esteem measurement poses the problem of getting sufficient variance of response in a situation where the respondent has had only a limited opportunity to judge the confidence he can place in the researcher. Further, some people will respond to such evaluative questions with a limited range of responses, whereas others will use a much broader range. Gordon (1966) observed this effect when he had project directors rate ten associates on their scientific or technical accomplishment. Some people were high differentiators (large variance in the ratings they provided), others were "levelers" (low variance).

Providing a limited set of pre-determined response categories, especially under the circumstances of the questionnaire administration, would probably have led to an unduly high proportion of low variance responses. A method of generating responses was desired that would lead to greater involvement on the part of the respondent, provide a wide range of response categories, automatically compensate to some extent for any propensity to not differentiate responses, and be interesting but not complicated to complete.

The method used was for the respondent to create his own scale that is self-anchored at three points. The extreme points are people for whom he has very high esteem or low esteem. For the high differentiator these points might be spread further apart in some "absolute" sense than for the low differentiator. Tying these end points to specific people meaningful to the respondent, rather than directly to the semantics of the adjectives used in fixed scales, was intended to establish some degree of comparability between the range of the scales used by individual respondents.

Since the responses are obtained only for the individuals in his own group and another group, the scale anchored at end points could only establish comparability between the two groups. Some indication of the respondent's mean level of respect for people is needed. This point could vary over a considerable range, so a third reference point was specified in terms of the respondent's conception of the norm for a typical technically trained person.

This scale is similar to the instrument currently being used by M. A. Lieberman in his studies of small group training activities.\* It also uses a key point followed by Apstein (1965) when he obtained rankings of the technical competence of military laboratories. He had the raters eliminate the names of any laboratories with which they were not sufficiently familiar to rate. Here this has been implicitly done through the respondent listing the names of the people he is rating.

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\* This was pointed out to the writer by Daniel Kegan who had received a copy of the instrument from Dr. Lieberman. The instrument is filed as #385 in the Instrument Inventory of the Program of Research on the Management of Research and Development.

Our scale is anchored at three points. The respondent is asked to think of the person he knows, either through personal acquaintance or his works, for whose technical or scientific activities he has great respect. The person may be living or dead, a member of the respondent's organization or not. The initials of this person are placed at the top of the scale. He is then asked to think of a particular person with technical responsibilities that he definitely does not respect and place him at the bottom of the scale, representing him with the letter "D" (to avoid any suspicions that the researcher would attempt to identify him). He was then asked to locate on the scale his conception of where the typical, technically trained "ordinary Joe" would fall, and to number the 15 bars on the scale so that he could indicate his esteem for each person on the worksheet.

In the field it was observed primarily from facial expressions and changes in individuals patterns of body movements that the objective of increasing the respondent's involvement was usually attained. A few respondents specifically commented that they found the "thermometer"--as it was called in the instructions--interesting to complete.

Five to ten minutes were required to complete the questionnaire, depending upon the number of names the respondent listed.

#### 4.5.7 - Respondent's Background

Demographic background data was obtained from each respondent to enable the study population and the composition of the groups to be described. This short questionnaire, CD Q05 entitled "Background Questions," was composed of 16 questions. The respondent's name, job title and department (or equivalent) were requested. The request for his name was marked "optional" and was included primarily to double check the pre-assigned code number--63% of the respondents did provide it. Four questions dealt with age and seniority: the respondent's age in one of four categories; his seniority (duration of employment with the organization) in five categories; his length of membership with the present group; and the length of time that the group had been in existence.

Four questions pertaining to the respondent's perception of his role in the organization were asked. One was his "job type." Three categories were provided--individual contributor or team member; project head, group leader,

supervisor, or other management or technical direction position; and technical or scientific advisor or fellow; plus an "other" category. He was asked if he would describe himself primarily as a scientist, engineer, supervisor or manager, or something else. He was asked what his particular specialty was, if any; and the extent to which he thought of himself as a specialist, for which a seven point scale was provided.

Educational history was determined by degrees received, their year, and the major field of each. The respondent's current technical field was also requested by asking him to check one of 12 categories (adopted from Rosenbloom and Wolek, 1967) or to fill in a blank line.

Events in the recent history of the organization could potentially have effects upon the relations between the groups. In addition to seeking such information during initial interviews with managers, two questions were included to alert the researchers to events potentially requiring investigation. These\* were:

In the last year have there been any major changes in the responsibilities of your group, such as starting new major projects, ending major projects, or major changes in workload?

In the last year have there been any major changes of management or policy affecting your group?

Since a person might be assigned to a work group administratively, but not actually function as a member of the group, the following question was included:

Is there anything special that might particularly set you apart from other members of your group in terms of what you work on, how you spend your time, your responsibilities, etc?

The version of this questionnaire used by Barth (RB Q05.1) had an additional multiple-part question to determine those individuals who acted in a liaison capacity:

As part of your responsibilities, are you acting, perhaps only part-time, as the formal liaison or coupling agent for your group? YES NO

If YES, please go on to the next section of the questionnaire.

If NO, are you acting informally as a liaison or coupling agent? YES NO

\* Provided by Dr. Charles W. N. Thompson.

If NO, please list the names of the formal and informal liaison or coupling agents of your group:

Formal agent: \_\_\_\_\_

Informal agent: \_\_\_\_\_

One to three minutes were required to complete the questionnaire.

#### 4.5.8 - Other Forms

Several other forms were utilized in the study. A general cover letter briefly explaining the purpose of the study and a guarantee of confidentiality was enclosed with all questionnaire packets. Also enclosed was a set of general instructions (CD C02). The participants were also invited to request a summary of the study with a third form enclosed with the questionnaires. This was done to provide the participants with the feeling that they would have the opportunity to get something out of the study in return for the time and effort they were about to invest in it. Potentially this same motivation could be provided by simply promising to send everybody a copy, but we felt that having the respondent make a definite decision, and committing himself to it by ignoring or writing on the page, would have a stronger effect. While the form was placed last in the packet, its presence and intent was specifically noted while explaining the content of the questionnaire packet. Since this form required a name and address, confidentiality was again emphasized by suggesting that it be returned in a separate envelope. Most participants returned the form with the questionnaires as suggested might be done in a footnote on the form.

Since there was normally a time separation of from two to eight weeks between the visits to a site by the two researchers, it would be possible for some event to have occurred that would have a significant impact upon the groups involved in the study. The second researcher included a short form with his packet of questionnaires, "Recent Changes" (CD Q11) which was designed to indicate if any such events had occurred. It has seven short questions that can be answered by circling YES/NO, or INCREASED/DECREASED/ABOUT THE SAME. If any changes had occurred, the last question asked for them to be briefly described. The forms described here will be found in Appendix 4A and the questionnaire in Appendix 4B.